Investigating critical sense in the interpretation of media graphs

by

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Declaration

I, Carlos Monteiro, declare that the work herein is my own and has not been submitted for degree at nay other institution. None of the work has previously been published in this form. Aspects of the pilot study and partial analyses have been published in the following papers:

Monteiro, C. (2002b). Critical sense and teaching about graphing: Challenges to schools. *Proceedings of II Summer School of YERME - Young European Researchers in Mathematics Education,* Klagenfurt University, Klagenfurt, available at: http://yerme2002.uni-klu.ac.at/papers/participants/cm_critsensgraph.doc.

Monteiro, C., & Ainley, J. (2002). Exploring critical sense in graphing, in S. Pope (ed.) Proceedings of the Day Conference of British Society for Research into Learning Mathematics at Nottingham University, Nottingham, 22 (3): 61-66.

Monteiro, C., & Ainley, J. (2003a). Developing Critical Sense in Graphing, *Proceedings of III Conference of the European Society in Mathematics Education.*

Monteiro, C., & Ainley, J. (2003b). Interpretation of graphs: Reading through the data, in J. Williams (ed.), *Proceedings of the Day Conference of British Society for Research into Learning Mathematics at Birmingham University*, 23 (3) 31-36.

Monteiro, C., and Ainley, J. (2004a). Exploring the complexity of the interpretation of media graphs, in O. McNamara and R. Barwell (eds.), *Research in Mathematics Education: Papers of the British Society for Research into Learning Mathematics*, BSRLM, London, vol. 6, 115-128.

Monteiro, C., & Ainley, J. (2004b). Critical Sense in interpretations of media graphs, in M. Høines and A. Fuglestad (eds.), *Proceedings of the* 28th *Conference of the International Group for the Psychology of Mathematics Education,* Bergen, Norway, v. 3, 361-368.

Monteiro, C., & Ainley, J. (2004c). Interpretation of media graphs and Critical Sense: Implications for teaching and teachers, *Proceedings of the 10th International Congress in Mathematics Education*, Denmark, available at: http://www.icme-10.dk

Monteiro, C., & Ainley, J. (2004d). Critical Sense in interpretation of graphs, *Proceedings of II Summer School of the Young European Researchers in Mathematics Education,* Charles University, Podebrădy, Czech Republic, available at: http://web.iol.cz/novotnya/

Abstract

This research explores elements and processes involved in interpretation of media graphs. The investigation was comprised of a literature review and a collection of empirical data. The literature review revealed a lack of qualitative evidence related to the complex relationships between elements and processes which comprise the interpretation of media graphs. This study explores the interpretation of media graphs by primary student teachers who would be involved in teaching about graphing. The main study was composed of two complementary datasets: questionnaires and interviews, which allowed an interplay between qualitative and quantitative data. 218 undergraduate and PGCE student teachers from Britain and Brazil responded to a questionnaire with items related to individual details, reading background and media graph tasks. 13 volunteers gave interviews which explored three types of questions: *reading the data*, *reading between the data* and *reading beyond the data*. The interviews also recalled the questionnaire responses. The data analysis of the questionnaires was software based, and a microanalysis approach was developed with the data from the interviews. The analyses of data gave evidence for the discussion about the notion of *critical sense* in graphing. It was concluded that *critical sense* in interpretation of media graphs is related to the *mobilisation* and *balance* of several aspects, such as: *mathematical knowledge, contextual reference, personal experience* and *affective exhibition*. The discussion of the results might help the reflection about teaching and learning of graphing in ways that will support the development of *critical sense*.

Chapter 1

Introduction

1.1 Setting the scene

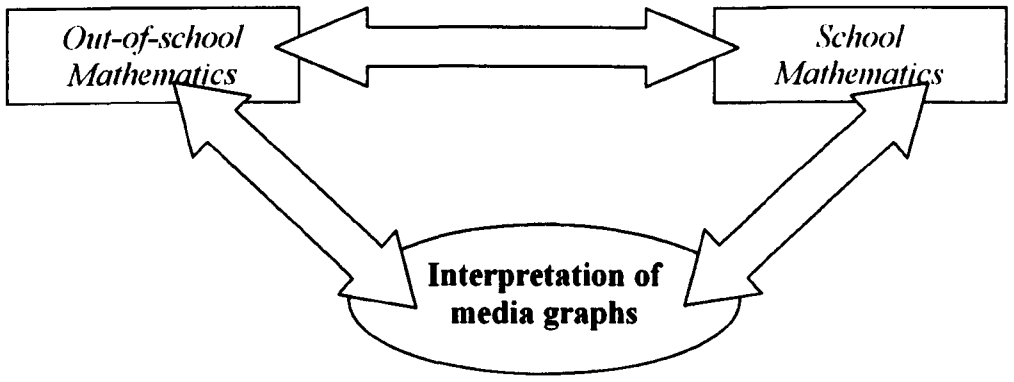
Since 1986, I have been involved in the mathematics education field. Supervised by Analúcia Schliemann I was a student research assistant in studies related to *street mathematics* (Nunes, Carraher and Schliemann, 1993). From 1995, I began to work in the teacher education programme in mathematics for primary school teachers in the Northwest of Brazil at the Universidade Federal de Pernambuco. As teacher and as researcher, my main interest has been establishing the relationship between psychology and education as an important aspect of the processes of teaching and learning mathematics. I am especially interested in investigating the nature and pedagogical implications of the relationships between *out-of-school* knowledge and experiences and those which characterise *school* practices.

In 1998, I concluded my master dissertation working with Luciano Meira. My project explored the process of interpretation of media graphs, which are statistical graphs published in newspapers, magazines, periodicals and other publications that provide news and information for the public. That study approached the utilization of mathematical knowledge among professionals similarly to previous studies in *street mathematics* (Schliemann, 1995). However, in contrast my study did not focus on specific mathematical concepts and procedures (e.g., arithmetical operations, area calculation, etc) and the participants did not have limited school experience. I specifically studied the interpretation of media graphs concerning economics among professionals with a high level of schooling (economists and business people), who had familiarity with this content, and/or frequently used graphs (Monteiro, 1998, 2002).

I expected that the interpretation of media graphs could be related to the participants' technical knowledge in graphing (*school mathematics*) and non-

academic mathematical knowledge and experiences associated with participants' daily lives (*out-of-school mathematics*). Figure 1.1 (below) illustrates these aspects of the interpretative process investigated.

Figure 1.1: mathematical components of the interpretation of media graphs



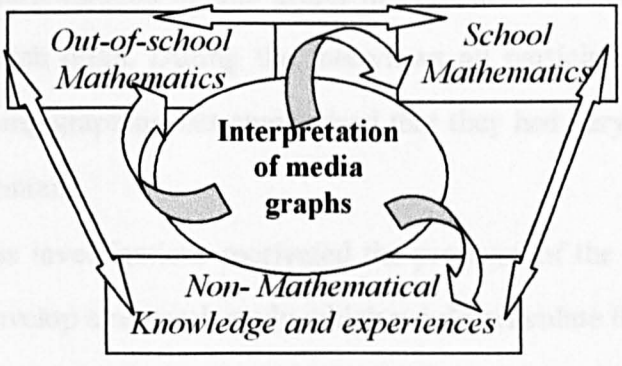
From this study I concluded that familiarity with the theme of graphs is not itself a facilitative aspect. The familiarity needs to be immersed in meaningful relationships between the interpreter and the graph. In other words, the importance of familiarity is not a pre-established aspect that happens independently.

Secondly, the academic qualification of the interviewees is only one part of their background. The economists and businessmen/women are also citizens, consumers, fathers and mothers, electors and so on. From such multiple backgrounds, interviewees brought their beliefs, desires, and knowledge about everyday situations to their interpretation. When the participants were interpreting the media graphs they *mobilised* their previous knowledge and experiences related to the data displayed. Therefore, mathematical competence in graphing was not the only aspect used to interpret the media graphs.

From this study I emphasised that the process of interpretation of media graphs are not only constituted for kinds of mathematical knowledge (*out-of-school* and *school*). The participants' interpretations were also associated with non-mathematical knowledge related to the data.

Figure 1.2 (below) represents the interpretation of graphs as a process which comprised different kinds of mathematical and non-mathematical knowledge and experiences, and the arrows suggest a complex relationship among those elements.

Figure 1.2: mathematical and non-mathematical components of the interpretation of media graphs



In Figure 1.2 the three main components of the interpretation of media graphs are connected by arrows which suggest a two way movement. On the other hand, the curved arrows from the interpretation of media graphs (in the centre) suggested that these components are dynamically interconnected.

The discussion of my findings added evidence to other similar studies which investigated aspects of the relationship between culture and cognition involved in interpretation of media graphs (e.g. Carraher, Schliemann and Nemirovsky, 1995; Meira, 1997).

My involvement in teacher education and the introduction of data handling as a topic of Brazilian official curricula (Brasil, 1997) motivated me to continue my exploration of the process of interpretation of graphs focusing on school contexts. Therefore, between 1998 and 2001, I was engaged in a research project that investigated the interpretation of graphs among primary school teachers (Monteiro & Selva, 2001). The interpretations given by the teachers suggested that they had low levels of familiarity with some terms related to the graphs (e.g. axes, scale), and some of them had difficulties in understanding quantitative relationships involved in the

data displayed. On the other hand, the data analyses revealed that the process of interpretation was based on teachers' opinions and feelings about the data. For example, one of the graphs was about the incidence of different types of cancer cases among men and women between 1990 and 2020. We observed that the personal involvement of participants with the topic of cancer seemed to be an important element of their interpretations of this graph in comparison to other graphs which composed the research tasks. During the interviews all participants recognised the importance of teaching graphing but emphasised that they had very little introduction to this curriculum content.

Those previous investigations motivated the proposal of the present study. My initial aim was to develop a research study which would articulate three main research interests: interpretation of graphs, relationship between *out-of-school* and *school* mathematics, and teacher education.

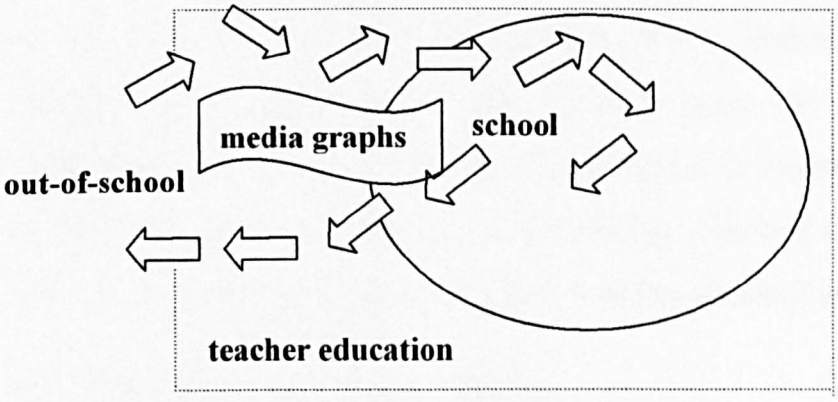
I intended to approach the interpretation of graphs as a process in which people can establish relationships between data, infer information, and consequently construct knowledge through the production, interpretation and presentation of graphs (Ainley, Nardi and Pratt, 1999; Shaughnessy, Garfield and Greer, 1996).

My interests in the investigation of interpretation of media graphs are related to a number of issues which seem to contribute to the complexity of this phenomenon. For example, despite misleading and disguising aspects related to media graphs (Meira, 1997) curricular designers (e.g. Brasil, 1997) suggest these graphs can be used as examples in the teaching about graphing. Some authors also suggest that the use of media graphs as a pedagogical resource can support a sceptical approach to statistics, an important aspect of citizenship (e.g. Watson, 1997).

This innovative use of media graphs as *out-of-school* resources in school practice as a result of curriculum reform generates challenges for primary schools. For example, teachers need to develop their own knowledge about interpretation and pedagogical approaches with media graphs.

The discussion of these issues related to interpretation of media graphs and teacher education added new elements to my research interests (see Figure 1.3 below).

Figure 1.3: The interrelations between aspects to be researched



In Figure 1.3 the arrows are pointing to different directions and simulating movement. This represents the complexity of the interpretation of media graphs as an activity which can establish relationships between *out-of-school* and *school* settings. The diagram also highlights the boundaries between the settings which include the teacher education contexts.

In his 'vari-focal' analogy, Skemp (1979) states that depending on focus, some phenomenon may be perceived through a 'bird's-eye view', or 'microscope's objective'. Using Skemp's ideas I consider Figure 1.3 as a 'magnified picture' of the problem. Therefore, an aim of the present study is establishing other focuses which can be perceived as the *interiority* of the interpretation of media graphs.

Initial attempts were made to focus on a specific aspect of the potential research problems represented in Figure 1.3. Therefore, I decided to investigate *critical sense* in the interpretation of media graphs which was temporally termed as an ability to look behind the data and deeply analyse information and its interrelations rather than simply accepting the initial impression given by the graph (Monteiro and Ainley, 2002).

This idea of *critical sense* in the interpretation of media graphs was developed through the several stages of this study. The trajectory of elaboration was adding complementary meanings for the term *critical*. For example, in initial phases of this

study I was influenced by perspectives which approach *critical* as related to being sceptical or to criticise the statistics displayed on media graphs. In further research stages I emphasise meanings of *critical* associated with the crucial dimension which *critical sense* has to mobilise and manage various elements which compose the interpretation of media graphs. On the other hand, the term *sense* originally highlighted the cognitive dimension of the process of interpretation of media graphs. In further stages *sense* also began to be explicitly related to other non-cognitive and affective elements and processes involved in interpretation of media graphs

1.2 The purpose of this study

This study intended to discuss theoretical ideas related to the critical dimension of interpretation of graphs among adults in general and particularly among primary teachers which illuminate the construction of the notion of critical sense in interpretation of graphs. Another aim for this present study was to generate empirical data which indicated primary school teachers displaying *critical sense* in their interpretation of media graphs.

The interconnection between the literature review and empirical evidence was intended to investigate the nature, components and processes associated with *critical sense* in interpretation of media graphs.

I anticipated as outcomes from this study a better specification of the components involved in the interpretation of media graphs. I also expected to generate evidence which support development of pedagogical approaches to help primary school teachers develop their own *critical sense*, and awareness of the importance of *critical sense* in their teaching of graphing.

1.3 The structure of this thesis

This thesis is composed of 9 chapters. This introduction is followed by two chapters which develop a literature review highlighting some aspects which might be important in understanding the elements and processes involved in the interpretation of media

graphs. Chapter 2 particularly discusses a number of aspects related to historical development, components, types and purpose of graphs as well as educational issues related to the use of graphs. Chapter 3 introduces theoretical ideas from several studies which approached different aspects associated with the complexity of interpretation of graphs, including those studies associated with *critical thinking, critical education* and affective aspects. These discussions helped to build the notion of *critical sense* in interpretation of media graphs.

Chapter 4 reports on the pilot study which had two important aims: to test methodological instruments to be used in larger scale in the main study and to focus the research problem on a specific aspects which would make the study achievable.

Chapter 5 discusses issues related to the definition of the method used in the main study. It presents the main elements related to the participants, research instruments of data collection, and outlines aspects of the data analysis.

Chapter 6 specifically presents findings from the questionnaires given to student teachers from university education courses in Britain and Brazil.

Chapter 7 discusses findings from interviews conducted with British volunteers.

In chapter 8, I discuss the outcomes from the empirical studies and the literature review for the investigation of the nature, components and processes associated with *critical sense* in interpretation of media.

Finally chapter 9 approaches pedagogical implications related to the development of strategies involved in teaching graphing that incorporate *critical sense* as a crucial aspect in teacher education and primary school curriculum. I suggest further research which can be based on the findings of this present study. I also describe my personal outcomes from the significant learning situations particularly associated with new methodological and theoretical aspects, which will result in an important improvement of my experience as researcher.

Chapter 2

Literature review - interpretation of graphs

2.1 Overview

Several authors have reviewed the literature associated with mathematics and statistics education which investigate the interpretation of graphs (e.g. Friel, Curcio, and Bright, 2001; Lajoie, Jacobs and Lavigne, 1993; Leinhard, Zaslavsky, and Stein, 1990; Roth and Bowen, 2001; Shaughnessy, 1992; Shaughnessy, Garfield, and Greer, 1996). These studies reveal an increasing number and variety of publications related to interpretations of graphs but also suggest a lack of research in the interpretation of media graphs and its pedagogical implications.

In this chapter and in the following chapter 3, I intend to develop a review of literature highlighting some aspects which might be important to understand the process and elements involved in the interpretation of media graphs, and particularly the notion of *critical sense* in interpretation of graphs. A number of aspects characterise this literature review. Firstly, the literature discussed is related to empirical research studies (e.g. Curcio, 1987, Watson, 1997) as well as publications which are based on author's own views without research evidence (e.g. Jones, 2000; Paulus, 1995). Secondly, the reviewed studies are associated with different areas, and methodological-theoretical perspectives. The rationale of this eclectic range of literature reviewed is to identify issues of interpretation from a wide variety of perspectives.

Thirdly, although I am interested in interpretation of media graphs, the majority of pieces of research reviewed in this study were related to the interpretations of Cartesian graphs developed by students from various schooling levels.

Finally, I underline the fact that this literature review was carried out continuously throughout all stages of this study. This aspect particularly contributed

to a continuing process of refinement of data analysis and the theoretical framework of this study.

The following sections of this chapter discuss a number of aspects related to historical development, components, types and purpose of graphs (Sections 2.2, 2.3, 2.4 and 2.5).

Further sections present educational issues related to the use of graphs. Section 2.6 introduces aspects associated with *statistical literacy*. Section 2.7 discusses literature related to the process of interpretation of graphs. Section 2.8 examines studies which investigated elements of contexts of interpretation of graphs. Section 2.9 discusses teacher education and the teaching of graphing. Finally, section 2.10 summaries this chapter 2.

2.2 The development of graphs

The term Mathematics comes from *Mathema* which was originally used to designate objects that were related to constructs and abstractions with which people could approach social situations (Machado, 1991). Mathematical knowledge was associated with the daily situations in which people were engaged. For example, Egyptians developed geometrical concepts to deal with divisions of agricultural areas on Nile River banks (Acioly, 1995). However, during the development of Western history there was a trend to emphasise the epistemological perspective in which mathematics was pre-established in a universe separated from the "real world".

Like other mathematical constructs, the development of graphs was influenced by different philosophical and theoretical perspectives. For example, Kuhn (1962) argues that Oresme (1320-1382) invented a new paradigm in which the graphical representations assumed an important role to play in displaying phenomena. In the seventeenth century, the development of Cartesian systems promoted a wider utilisation of graphs as a mathematical resource which provided the presentation of abundant experiments in different scientific areas (Biderman, 1989).

Carvalho (2001) states that the term *Statistics* comes from the Latin word *Status* which means state. Statistics was initially developed as an official resource which enabled the government to emphasise its social and economical outcomes, and during the Industrial Revolution, Statistics became a vital resource for capitalists who needed to analyse incomes. According to Carvalho, Statistics was introduced as an academic field in 1748 by Gottfried Achenwall.

Graphs seemed to be a useful statistical resource for presentation of data. William Playfair made an important step in the development of the statistical graphs publishing *The Commercial and Political Atlas* (Playfair, 1786) that comprised 44 graphs, including the first statistical bar graph. In contrast to Cartesian graphs which were used to present results of experiments (Tilling, 1975), Playfair's graphs could spatially describe non-spatial quantities (Birdeman, 1989). For instance, his bar graphs expressed the revenues and expenses of Scotland, in which space was not a variable.

Tufte (2001) quotes Playfair's explanation which argues that his charts correspond to a physical realisation of the data.

> *"Suppose the money we pay in any one year for the expence of the Navy were in guineas, and that these guineas were laid down upon a large table in straight line, and touching each other, and those paid next year were laid down in another straight line, and the same continued for a number of years: these lines would be different lengths, as there were fewer or more guineas; and they would make a shape, the dimensions of which would agree exactly with the amount of the sums; and the value of guinea would be represented by the part of space which it covered. The charts are exactly this upon a small scale, and one division represents the breadth or value of ten thousand or an hundred thousand guineas as marked, with the same exactness that a square inch upon a map may represent a square mile of country. And they, therefore, are a representation of the real money laid down in different lines, at it was originally paid away" (Playfair, 1786, pp. iii-iv).*

Cartesian graphs and Playfair's graphs were different because each one had a specific relationship to the domain of Mathematics. On the one hand, Cartesian graphs used by 18th century scientists served to present results of experiments which confirmed general scientific principles expressible as a mathematical function (Tilling, 1975). On the other hand, Playfair graphed data which did not have direct conformity with mathematical principles. Playfair's graphs did not display the mathematics applicable

to data, but they used mathematics to facilitate the visual display of data (Biderman, 1989).

Although Playfair graphed data with very professional techniques and devices (e.g. use of colours and precision of measures of the bars or sectors), he had the pragmatic purpose of facilitating the work of busy businessmen. He believed that his graphs could quickly show information which might take days to be read if it was presented by tables. Birdeman states that Playfair was more a 'skilled draughtsman' than an academic but his graphs were prototypes for modern statistical graphs.

Carvalho (2001) argues that statistics gradually moved from the status of official resources generated by governments. In the 19th century, Pearson (1857-1936) and Galton (1822-1911) developed aspects of statistics which made possible the application of the graph form related to abstract universal as well as idiographic principles. On the other hand, Carvalho also emphasises that systematic approaches based on probabilistic theoretical perspectives promoted the development of inferential statistics which added significant possibilities for the application of statistics. This discussion of the origins and development of statistical graphs suggests that their conceptualisation and use is related to a complex range of elements which includes different paradigmatic mathematical and statistical perspectives as well as social and cultural factors.

Although the consideration of the dynamic process of the development of graphs does not suggest an immobile standard composition of graphs, there are specific structural elements which constitute current types of graphs (Friel, Curcio, and Bright, 2001). The components associated with graphs are presented in following section 2.3.

2.3 Components of graphs

The term graph can have different meanings in mathematics, statistics, education and other fields, depending on the purpose, the perspective and the situation in which it is applied (Wainer, 1992). In this study the term graph is related to the statistical graphs

which in general are comprised of common structural components such as: framework, specifiers, and labels (Friel, Curcio, and Bright, 2001).

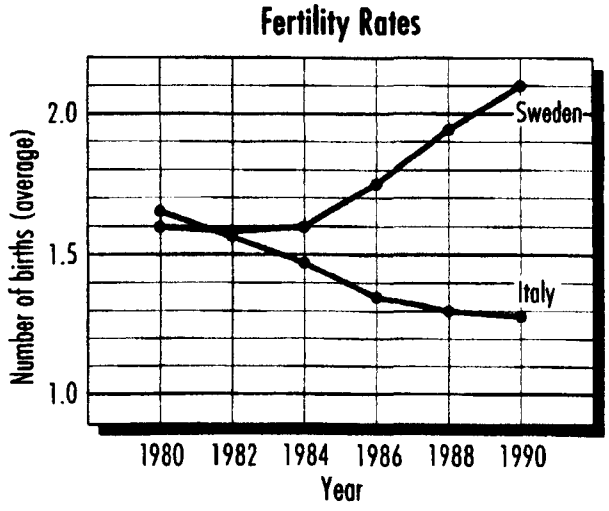
a.) **Framework**:

The framework comprises axes, scales, grids, reference marks etc. The simplest framework has an L shape in which each leg is a denominated axis. The Y axis is vertical, and usually gives information about the kinds of measurements being used. The X axis is horizontal, and stands for the data being measured (Kosslyn, 1994).

b.) **Specifiers**:

The *specifiers*, also called *content* (Kosslyn, 1994), are visual dimensions used to represent data values. They might be the lines, bars, point symbols, or other features that specify particular relations among the elements represented by the *framework*. Figure 2.1 (below) shows a graph in which the positions of the specifiers are plotted as values along the **y** axis (*average of birth numbers*), and are paired with values along the **x** axis (*years*).

Figure 2.1: *Social policy and recent fertility changes in Sweden* by J.M. Hoem, *Population and Development Review*, December 1990, cited in *The Economist*, 13 April 1991, p.47 (reprinted from Kosslyn, 1994).



c.) **Labels**:

Kosslyn describes a label as another graphical component. For example, in Figure 2.1 the axes of the framework bears a label naming a dependent variable (the type of measurement being made – e.g. "Number of births [average]") or an independent variable (the entity to which the measurement applies – e.g. Year). Other

labels indicate values along the measurement scale (e.g. specific number of births – 1.0, 1.5, 2.0), and the particular units that were measured (the years 1980, 1982, 1984...).

Graphs might also contain a number of optional components such as a caption, which comments on the display. This can be a short description that explains key terms or directs the reader's attention to specific features of the display (Kosslyn, 1994).

Kosslyn emphasises that this breakdown of a graph into components might help the investigation related to graphs because it specifies the purpose of each element. On the other hand, this approach seems to be restrictive because graphs are more than the sum of their parts. Therefore, although this subsection presents some of the components of graphs it consideres the limitations of this type of description which isolates the components from the whole graph and from the context in which it is produced and interpreted.

The classifications of the elements of graphs produced by several authors (e.g. Friel at al., 2001; Jones, 2000; Kosslyn, 1994) emphasises the "apparent" components displayed on the graph. However, the consideration of "latent" components is also fundamental for the analysis of graphical structure. For example, Figure 2.1 (above) describes specifiers or contents which include different variables (fertility rate, country, and years). However, there are other aspects which are not explicit, such as: the choice of Sweden and Italy, and the chosen years. There are also other specifiers which are not displayed in Figure 2.1 which might be important in making sense of the data presented. For example, specific information about this content might play a fundamental role: the concept of fertility used, the gender, and age of people who composed the sample.

The variety of elements which comprises graphs is also associated with a diversity of types of graphs. In the next section, some of these types will be introduced.

2.4 Types of graphs

Most statistical graphs are constructed based on an L-shaped framework comprising two axes which are denominated X and Y. The choice for a type of graph should be related to the kind of data that will be displayed (Friel et al., 2001). Generally, the most frequent graphs are the line graphs, bar charts, pie charts and pictograms.

Bar graphs

This type of graph presents quantities represented by specific bars. Each bar reflects the separate categories of such data (Haack, 1979). Generally, bar graphs are associated to time-series data. The bar graphs are very frequent in the print media (Lima, 1998; Monteiro, 1998).

Line graphs

Line graphs are constructed for correspondence between elements of both axes. The lines link the points of correspondence. This type of graph is more suitable for discussing continuous variation of categories (e.g. variation along certain period of time, see Figure 2.1 at section 2.2).

Pie Charts

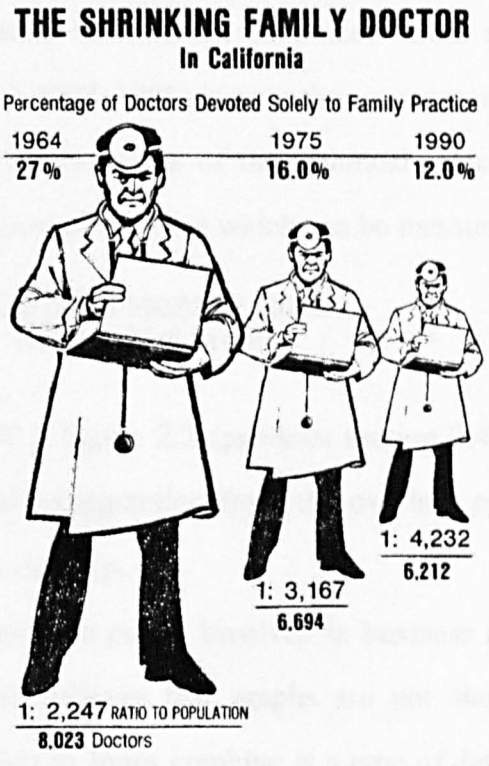
This kind of graph is metaphorically called pie because its circular shape is similar to a pie form. For the same reason, in some countries, it can be called "pizza graph" or "camembert graph". The procedure of production of a pie chart demands the transformation of a total figure in 360° of a circle (Jones, 2000). The numerical values, which will be represented for sectors, must correspond to fractions of 360°.

Pictograms

Tufte (2001) defines pictogram as a type of graph which combines the data variation with design variation (See Figure 2.2 below). According to Tufte the proper graphing technique requires that the areas of pictures be proportional to the numbers they represent and the labelling should be thorough, clear, and detailed, which can avoid graphical distortion and ambiguity. However, this is not always the case in graphs published by print media. For example Figure 2.2 is a copy of a media graph

which does not have explicit axes and the physical measurements on the surface are not directly proportional to the numerical quantities represented.

Figure 2.2: *Los Angeles Times*, August 5, 1979, p.3 (reprinted from Tufte, 2001).



As discussed in section 2.2, the development of graphs is associated with social uses in specific historical situations. These 'adaptation' processes generate a larger number of possibilities for types of graphs, such as: plot graphs which have T-shaped frameworks (Tukey, 1977); multidimensional diagrams which are an alternative to polar coordinates graphs (Upton, 1999); hybrid graphs which are a combination of two different types (Jones, 2000). Although this subsection could not describe all types of graphs, the types presented will support the discussion of the interpretation of graphs which comprised the research tasks of the empirical studies (see chapters 4 and 5). In the next section I introduce aspects associated with the presentation of data in those different types of graphs.

2.5 Graphs presenting data

Several authors emphasise that presentation of data by statistical graphs must follow certain technical requirements, such as the use of the basic graphical components and the proportional relationship between the numerical values and their representation. For example, Tufte (1990, 1997, 1998) is an author concerned with visual display and design. He argues that the violations of the technical principles by poor designers constitute one form of misrepresentation which can be measured by a *lie factor*:

$$\textbf{Lie factor} = \frac{\text{size of effect shown in graphic}}{\text{size of effect in data}}$$

According to Tufte (2001), Figure 2.2 (previous section 2.4) has a *lie factor* of 2.8 excluding "the additional exaggeration from the overlaid perspective and incorrect horizontal spacing of the data" (p. 69).

Jones (2000) writes for a public involved in business fields which need to use and interpret graphs. He believes that graphs are not simply neutral vehicles of communication. According to Jones graphing is a type of data reduction whereby the complex world impinging on readers' senses can made simpler, and thus easier to understand. Jones emphasises that this data reduction is not necessarily a bad procedure but it has to be done carefully.

The 'reduction' of data might be related to factors which precede the production of graphs. An instance comes from Haack (1979) who is a statistical researcher concerned with graphical data presentation. He exemplifies the use of variables such as age and educational achievements which are statistically approached as continuous sets of data. According to Haack, age is frequently recorded to the last birthday or discretely (0, 1, 2, etc), but the exact age of two people can vary by smallest amount of time. On the other hand educational achievement is crudely measured by years of school completed although education is continuous process. Therefore, the numerical data which express these two indicators are a reduced picture of the 'reality'. The

further manipulation which might be done when this data is displayed graphically might 'reduce' the data in other terms.

These authors who discuss the interpretation of graphs (Haack, 1979; Jones, 2000; and Tufte, 2001) introduce interesting ideas about the interpretation of graphs such as those which we find in print media. However they do not present empirical evidence based on research studies. These commentaries also seem to attribute an excessive power to graphical representation minimising the role of the reader. These authors argue that graphs can be misleading or be used to mislead. However they seemed to believe that it is possible to produce perfect graphs which achieve certain appropriate ranges of technical norms to guide the reader. For example, Tufte (2001) established the notion of *graphical excellence* as a well-designed presentation of data which requires telling the truth about the data to the viewer with clarity, precision, and efficiency.

An alternative perspective about displaying data is given by authors who are based in empirical investigation. For example, Arcavi (2003) emphasises both components of graphs and processes related to the display of data. He introduces a concept of visualisation which is not only related to the graph itself:

> *"Visualisation is the ability, the process and the product of creation, interpretation, use of and reflection upon pictures, images, diagrams, in our minds, on paper or with technological tools, with the purpose of depicting and communicating information, thinking about developing previously unknown ideas and advancing understandings" (p.217).*

Arcavi criticises an almost commonplace statement that we live in a world where information is transmitted mostly in visual wrappings, and technologies support and encourage communication which is essentially visual. He emphasises that the complexity of the phenomenon of visualisation is not only related to what comes "within sight", but we are also encouraged and aspire to see what we are unable to see.

I recognise that the claims about the misleading displays of data which media graphs might have are important elements to be considered. However, the complete

absence of errors or "graphical excellence" (Tufte, 2001) cannot be a guarantee of "successful" interpretation. The consideration of the complex range of components and processes (e.g. Arcavi, 2003) involved in the displaying and interpretation of graphs emphasise the importance and role of the reader as well as the graph.

In the next section, I discuss elements of the *statistical literacy* which are more closely related to the elements which enable the reader to interpret a graph.

2.6 Statistical literacy

The term statistics has different meanings: subject, method, data and/or numbers (Rowntree, 2000). Statistics can also be distinguished as *descriptive* or *inferential*. According to Haack (1979), *descriptive statistics* is used to summarise or describe particular characteristics of a data set, while *inferential statistics* is used to make estimates and predictions based on a collection of data.

Statistical literacy is a term used to describe the knowledge which people need in order to understand and make decisions based on the analysis of statistics. For example, when people interpret statistics they need to consider and to scrutinise certain aspects which include the source, the type of data, definition and measurement problems, certain considerations concerning survey sample (Haack, 1979). According to Haack, readers should scrutinise statistical statements as carefully as we sometimes scrutinize verbal and written statements. The situation in which the statistics are not scrutinized is the single most important reason for misuse of statistics. As most authors who began to develop the concept of *statistical literacy*, Haack emphasises elements which are basically related to the technical dimension of statistics knowledge. This perspective of *statistical literacy* seems to be based on standard academic uses of statistic such as those developed by professionals who needed to use statistical approaches to conduct research in specific areas (economists, psychologists etc).

However, new implications for the conceptualisation of *statistical literacy* were introduced by the popularisation of the access to statistics. Writers such as Huff

(1954) and Paulos (1995) develop discussions which were an embryonic movement which emphasises the need of media readers to develop and use a minimum of statistical knowledge to enable them to understand statistics critically.

A wider perspective of *statistical literacy* is introduced by Evans (1992) who investigates the kinds of statistical skills which are needed by adults in everyday life. Evans suggests the notion of *barefoot statisticians* who are community leaders. They present statistical information in terms that are both comprehensible to their community, and powerful in the discourses within which they may sometimes need to argue, for example, with agents of state bureaucracy. Similarly, Roberts (1990) developed the idea of *parastatisticians* which are not only resource persons within an organisation (like *barefoot statisticians* with their community), but also 'ordinary' managers with basic statistical capabilities.

Gal (2002) emphasises that the need for *statistical literacy* for all citizens who interpret statistics in various everyday situations. For example, Gal suggests that when people read statistics from media they have to make inferences, quite often in the presence of irrelevant or distracting information, and perhaps also apply mathematical operations to data contained in graphs. The media graphs are particularly used to illustrate journalistic arguments which emphasise and/or disguise aspects of data (Meira, 1997). Therefore, Gal emphasises that *statistical literacy* should enable readers to interpret, critically evaluate, and comment on the data. Figure 2.3 (below) illustrates Gal's perspective of *statistical literacy*.

Figure 2.3: A statistical literacy model, adapted from Gal (2002).

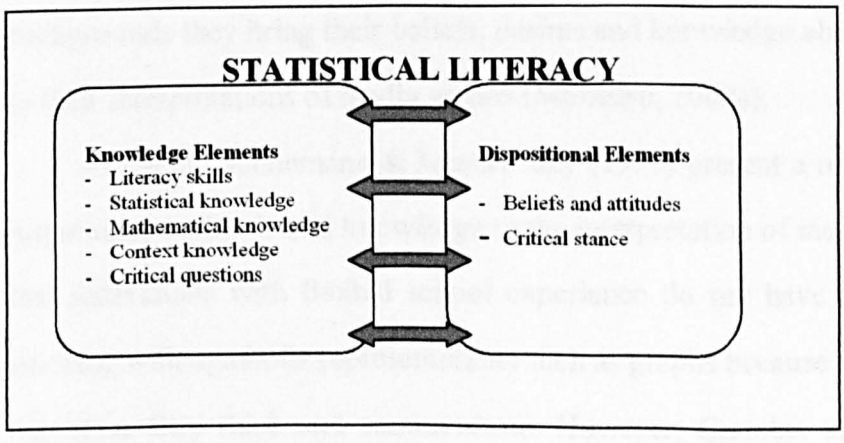


Figure 2.3 represents two ranges of elements which when combined can enable readers to understand statistical messages. On one side of the diagram there are *knowledge elements* which involve *cognitive* components of the *statistical literacy* (e.g. rational understanding of the data such as to know how to decode and make calculations about it). On the other side are presented *dispositional elements* which comprise a range of 'non-cognitive' aspects (e.g. a person who interprets a graph can have knowledge, experiences and beliefs which might differentiate his/her interpretation of the graph). According to Gal, *statistical literacy* is based on the interaction of the components which comprise each range of elements. Gal's perspective of *statistical literacy* considers more explicitly the important role to the person who interprets rather than "universal principles of perception" (Kosslyn, 1994) or "the excellence in displaying data" (Tufte, 2001) attributed to the graph itself.

Gal's *statistical literacy* model underlines that the academic or formal schooling background is not the only determinant of use of statistical skills. I also identified this aspect in a previous study (Monteiro, 1998, 2002a) which investigated the interpretation of media graphs among high qualified economists who utilise graphs in their professional everyday activities. They developed interpretations which do not consider important aspects displayed on media graphs. Although they have formal knowledge about the graphs and the topic presented by the graphs, they also used a range of informal knowledge to interpret the graphs. When these professionals were reading they acted as whole people who play other roles in everyday life. They were also citizens, consumers, fathers and mothers, electors and so on. From such multiple backgrounds they bring their beliefs, desires and knowledge about everyday situations to their interpretations of media graphs (Monteiro, 2002a).

Carraher, Schliemann & Nemirovsky (1995) present a relativist view about the importance of the formal knowledge to the interpretation of media graphs. They argue that individuals with limited school experience do not have a general difficulty in working with symbolic representations such as graphs because everyone uses symbols whenever they think and communicate. However, Carraher and his colleagues also

acknowledge that a person with a limited schooling level may not appreciate some elements involved in a graph.

The increasing discussion about *statistical literacy* raises certain issues. For example, Carvalho (2001) emphasises that several authors view *statistical literacy* as a panacea to solve lack of statistical knowledge in several sectors of the society (e.g. Wallman, 1993). However, Carvalho highlights the need to discuss issues related to development and transferability of *statistical literacy.*

Even considering more holistic approaches of *statistical literacy* such as Gal's perspective it is necessary to consider possible gaps and limits of the theoretical models. For example, I see the two ranges of elements of Gal's model as emphasising a dichotomy between cognitive and non-cognitive elements of *statistical literacy.* In addition, I see the *dispositional elements* are not entirely defined. Are these components inherent to the readers? Can these elements emerge from the situation of interpretation of data?

In this present study I focus on a specific aspect of *statistical literacy* which is the interpretation of media graphs published by print media. In the following section I discuss research studies which investigate the interpretation of graphs.

2.7 The research in interpretation of graphs

The interpretation of graphs is a research topic of several studies from different areas, such as: mathematics education (e.g. Ainley, 1995; Janvier, 1981, Pratt, 1994), statistics education (e.g. Watson, 1997), science education (e.g. Berg and Philips, 1994; Jackson, Edwards and Berger, 1993), psychology (e.g. Carvalho, 2001; Guimarães, 2002; Selva, 2003), communication (e.g. Orcutt and Turner, 1993), language (e.g. Shah and Carpenter, 1995), perception (e.g. Kosslyn, 1994); statistics (e.g. Haack, 1979); physics (e.g. Brasel and Rowe, 1993; McDermott, Rosenquist, and van Zee, 1987).

In this section I review several studies related to different theoretical and methodological perspectives. I consider that such discussion might have limitations

because it compares research which has different epistemological claims and purposes. However, this diversity of approaches can also give a wider picture of the findings which would support the core of this study: the discussion of *critical sense* in interpretation of media graphs.

Due to this diversity I decided to structure the discussion through subsections related to main aspects of the studies reviewed. Therefore the following subsections approach respectively: studies which emphasise the misconceptions and errors in interpretation of graphs (2.6.1); the influence of other aspects to interpretation of graphs (2.6.2); assessment in interpretation of graphs (2.6.3); and interpretation of media graphs (2.6.4). However, some studies are related to more than one subsection.

2.7.1 Misconceptions and errors in interpretations of graphs

Several studies which investigated the interpretation of Cartesian graphs were comprised of a categorisation of 'errors', 'misconceptions' or 'difficulties' of the students (e.g. Bell, Brekke and Swan, 1987; Clement, 1985; Leinhard, Zaslavsky and Stein, 1990).

The research approaches offered various explanations for the student's mistakes:

- Goldenberg (1988) and Clement (1985) suggest that difficulty related to the interpretation of graphs is associated with the complexity of the representational systems which comprise the graphs.

- Leinhard et al. (1990) emphasise that students' difficulties in understanding graphs are related to technical (formal) aspects of graphing.

- Berg and Phillips (1994) suggest that difficulties are related to students' cognitive deficits.

I have identified that some of the previous literature reviews (e.g. Friel, Curcio, and Bright, 2001; Roth and Bowen, 2001) state that the studies which emphasise the errors were only developed in the 1970's and the 1980's. I did not find this

necessarily true because very recent studies have emphasised misconception in interpretation of graphs (e.g. Guimarães, 2002; Wu, 2004).

2.7.2 Assessment in interpretation of graphs

A classical study in the assessment of interpretation of graphs was developed by Kerslake (1981). She reports on the CSMS study which tested primary and secondary students evaluating their knowledge about graphs. The questions used involved ideas of coordinates, the use of scales, the notion of gradient, continuity and the use of algebra and equations. The results revealed that almost all students were able to answer correctly items which were classified as a low level of complexity, such as questions related to block graphs and other pictorial representations of numerical information and the plotting of points on a coordinate grid. However Kerslake comments that the results also exposed a large gap between the relatively simple reading of information from a graph and the appreciation of an algebraic relationship. This author argues that the knowledge which facilitates children to appreciate visual displays of information that appear in newspapers and magazines is not sufficient. Children must continue learning other abilities to achieve the apex of knowledge in graphing which is a study of functions where they find how powerful graphical methods can be.

Kerslake's perspective is based on a traditional view of graphing which is compartmentalised in hierarchical sub-skills (Ainley, 1995; Swatton and Taylor, 1994). In that case most of the students tested only reached elementary levels. This type of perspective is similar to a considerable number of studies which give evidence which supports the view that graphing was a difficult topic for secondary students (e.g. Padilla, McKenzie, and Shaw, 1986). According to Ainley (1995) this research perspective is based on traditional views of teaching and learning which do not consider a complex range of aspects related to interpretation of graphs.

Hadjidemetriou and Williams (2000, 2001a, 2002a) discuss the development and validation of a 'graphical assessment' tool which is an update and extension from

previous approaches in 'graphicacy' assessment (e.g. Kerslake, 1981). The instrument of assessment was used with British secondary school pupils (14 to 15 years old) and items were related to Cartesian graphs of function. The items which comprised the research questionnaires were deliberately posed in such a way to encourage relevant misconceptions to come to surface. Therefore Hadjidemetriou and Williams conclude that their diagnostic items described not only children's graphical thinking but also some of the most common errors and misconceptions.

Friel, Curcio and Bright (2001) emphasise that important contributions to understanding the process of the interpretation of graphs were made by authors who investigate assessment tasks composed of kinds of questions that graphs can be used to answer (Bertin, 1967; Curcio, 1981; McKnight, 1990; and Wainer, 1992). According to Friel et al. there is a consensus among these authors that attribute three levels of graph comprehension: an *elementary level* focused on extracting data from a graph (i.e. locating, translating); an *intermediate level* characterised by interpolating and finding relationships in the data as shown on a graph (i.e. integrating, interpreting), and a *overall level* which requires extrapolating from the data and analysing the relationships implicit in a graph (i.e., generating, predicting). Generally, these authors found that their participants experienced few difficulties at *elementary level*. However, the participants made errors when they encounter *intermediary level* and *overall level* questions.

Curcio's terminology (1981) is normally used for these three levels of graph comprehension: *reading the data*, *reading between the data*, and *reading beyond the data*. This author emphasises that graphs might be viewed as a type of text which is structured by three main components: topic, mathematical content and graphical form. According to Curcio, the effect of prior knowledge about structural elements of the graphs influences the reader's ability to comprehend mathematical relationships expressed in graphs. However, Friel, Bright and Curcio (1997) argue that the process of interpretation involves extrapolating from the data displayed on the graph, which suggests that students build on what they already know. Thus, readers use their

background knowledge and experience when processing information, whether they are reading prose, tables, or graphs.

Even though Curcio's perspective has contributed to understanding nuances of the interpretation of graphs, this approach only investigates the kinds of graphs traditionally used in schools. These graphs have limited purpose, in terms of analysing or communicating information that relates to problems of interest to the students who interpret them. In addition, Curcio's approach only highlights technical aspects of graphs. For example, the three different types of reading can be developed in interpreting a graph which is technically accurate but which might present unrealistic and incoherent data. Therefore, we might read beyond the data (extrapolating, predicting, or inferring from the representation) without being prompted to question the main idea presented in the graph. Curcio did not investigate how students evaluate and criticise the information displayed, what was criticised by Shaughnessy, Garfield and Greer (1996) who also suggest a fourth type of question: "looking behind the data" questions involving consideration of how and from where which data sets arise.

On the other hand, Gal (1998) suggests only two levels of questions: *literal-reading* and *opinion*. Gal emphasises the challenge of *opinion* questions because they require the assessment of opinion rather than facts about the data displayed.

2.7.3 Influence of other aspects in interpretation of graphs

Some studies have investigated the relationship or influence of another aspect in the interpretation of graphs. For example, Janvier (1979) investigates the interpretation of graphs by secondary students which display data related to certain situations such as the speed of a racing car varying along a 3km track during its second lap. Janvier (1981) argues that the use of a situation is not the panacea which guarantees 'concretisation' of abstract notions related to graphs (e.g. variables and concepts such as speed and acceleration). He emphasises that during the interpretation of graphs individual processes of abstraction are activated. Such processes are related to

personal experiences which are brought into various interpretations of the goals of a task and the range of strategies which determine its level of complexity.

Janvier bases his study on a psychological perspective in which the interpretation of graphs involves a retrieval process of encoded information in the memory controlled by two mediators, one verbal and one imagined. On the one hand, the graph has to be considered symbolically (e.g. pictorial similarity with elements of tracks has to be disregarded). On the other hand, the tracks (picture) have to be analysed at certain abstract level which must go beyond driving performance.

Janvier (1981) underlined that the difficulties presented by students might be a direct result from the type of teaching activity. Particularly, he argues that the excessive use of worksheets in classrooms, which replaces spoken explanation by written information, does not allow teachers to evaluate all aspects related to the students' interpretations.

A number of research studies have investigated the effect of the construction of graphs on interpretation (e.g. Mevarech and Kramarsky, 1997). Berg and Smith (1994) particularly examine the relationship between construction and interpretation of graphs and logical thinking. They suggest that the construction of graphs leads to higher levels of cognitive engagement by forcing students to attend to the local processes and subsequently they reach an understanding of the more global interpretation.

Shah and Carpenter (1995) recognise that verbally describing and interpreting graphs are tasks which are representative of the ways that graphs are used in reading situations. From their experiments they also conclude that verbal description is an important element because it can influence the participants' comprehension of graphs.

Selva (2003) investigates the interpretation of bar graphs associated with manipulative materials. Her findings indicate that pedagogical activities about graphing which are connected with other forms of representation, facilitate the understanding about graphs of primary school students.

Swatton and Taylor (1994) explored the performance of students interpreting graphs in relation to the ability to handle variables. Swatton and Taylor highlight that the description of the relationship displayed on the graph proved to be the most difficult demand. The pupils' "descriptive" performance was characterised for low frequency of responses which actually did bring both variables together as a full pattern statement. According to Swatton and Taylor, pupils apparently see the graph more as a "picture" of one variable rather than a model of a deeper underlying relationship between the two variables.

The findings from Swatton and Taylor also suggest the importance of informal knowledge during the process of interpretation which was examined by other authors as well. Generally the authors see informal elements as "interference" in the interpretation. For example, Leinhurdt et al. (1990) suggest that students' conceptions rooted in their experience should be avoided through learning about conventions of Cartesian graphic representation which helps students to better understand how to represent the relationships between variables.

On the other hand, other authors view informal knowledge as fundamental to the interpretation of graphs. For example, diSessa, Hammer, Sherin, and Kolpakowski (1991) explored graphing among primary school children. They focused on meta-representational competence which is the faculty to generate, critique, and refine representational forms. In their study a teacher asked children to describe some situations of motion. Analyses of data revealed that the graphical representations produced by the children did not correspond to their whole understanding about the situation described. For example, the omission of elements of relation between time and speed in graphical representation did not necessarily mean a complete misunderstanding about the motion described. diSessa and his colleagues discuss the limitation of evaluative procedures in graphing which takes the representations as the only parameter of what the children understand about the described situation. The authors emphasise the complexity of representation processes that include production and attribution of explicit and implicit meanings. diSessa et al. (1981) suggest that

analyses of meanings should be based on what is 'proposed' by teacher, 'perceived' by pupils, and 'negotiated' by the class group. Therefore these authors see the role of the pedagogical context and non-formal knowledge as important aspects of the teaching and learning in graphing. Other studies also investigated non-formal aspects of graphing activities in which school pupils were involved (e.g. Tierney and Nemirovsky, 1991; Tierney, Weinberg and Nemirovsky, 1992).

2.7.4 Interpretation of media graphs

The literature review carried out as part of this study revealed that a reduced number of studies approached the interpretation of media graphs. This subsection discusses some of these studies. For example, Orcutt and Turner (1993) examine how journalists and graphic designers in the USA's print media transformed modest yearly changes in time-series data related to cocaine consumption into graphs which suggest an epidemic of the phenomenon. The sociological analysis of these authors identifies evidence of the fabrication of the data through "creative choices and skills" (p.204).

Joram, Resnick and Gabriele (1995) analyse the frequency and characteristics of numbers in USA's popular magazines written for children teenagers and adults. Their findings indicate that difficult mathematical concepts that appear in the media, such as fractions, percentages and averages are more prevalent in adults' magazines. However, in this study the authors did not include the numbers presented by graphs. According to Joram and colleagues, the media graphs would disproportionably inflate the count of rational numbers in the text analysed because graph can contain a very high frequency of numbers.

Hinders (1990) and Watson (1997) argue that the media provide examples of graphs which can motivate teaching and learning about graphing. Watson, Moritz and Pereira-Mendoza (1998) observed that the poor performance of students in interpretation of graphs tasks is associated with the type of task which is utilised to assess their interpretation of graphs. Watson believes that the utilisation of media

graphs can offer a meaningful 'context' for the teaching related to the interpretation of graphs.

Watson (1997) suggests a three-tiered hierarchy for assessing *statistical literacy* based on authentic extracts from the media, which include graphs:

> Tier 1: Basic understanding of statistical terminology.
>
> Tier 2: Understanding of statistical terminology embedded in wider social discussion.
>
> Tier 3: Being able to question unrealistic claims made by the media or others. A questioning attitude that can apply more sophisticated concepts to contradict claims made without proper statistical foundation.

Watson states that at the highest level of the statistical thinking hierarchy, students have the confidence to challenge what they read in the media. She highlights the tendency in media contexts for claims to be made without proper statistical foundation, either inadvertently or sometimes purposefully. Therefore, whether there is an intention to mislead or just insufficient information, students need to be made aware that they must constantly question conclusions.

Watson suggests that unusual and misleading graphs, which occur in print media, might be excellent examples to motivate and challenge students. Watson argues that the purpose of this type of assessing interpretative task is to discover if students can move to higher levels of cognitive functioning than are generally required to perform computation.

2.8 Contexts of interpretation of graphs

Several authors who investigated the interpretation of statistical graphs particularly emphasise the "context" as an important element which influences the interpretation of graphs. However, it seems these authors used the term 'context' in different ways. For example, Watson (1997) seems to emphasise the influence of the graphical task itself.

Other authors used the term context referring to a wider perspective. For example, context can be related to the extended process in which students are engaged in graphing activities. For example, Schoenfeld, Smith and Arcavi (1993) emphasises that learning to understand and be competent in the handling of multiple representations can be a long-winded, context dependent, non-linear and even tortuous process for students.

According to Evans (1999) in order to consider interrelations between different contexts of use of mathematics, such as those related to the interpretation of graphs, one should analyse the particular practices at play in them. For example, the basic positions available in school mathematics are normally 'teacher' and 'pupil'; in shopping or street-selling, they would be 'seller' and 'buyer'. Evans criticises the isolation of 'situation' (part of the context that provides the overt background to problem-solving activity) from the context.

Meira (1997) argues that the analysis of readers' interpretations of media graphs must consider formal and informal aspects associated with both graphical representation and reader. Meira highlights that reader and graph must not be considered in isolation because they are very closely related during the process of interpretation.

Another perspective of context is developed by Gal (2002) who suggests two main kinds of contexts in which the interpretation of graphs might be developed: 'enquiry' (as suggested by Wild and Pfannkuch, 1999) and 'reading'.

In *enquiry contexts* people act as 'data producers' and usually have to interpret their own data and report their findings (e.g. researchers and statisticians). Wild and Pfannkuch investigate complex thought processes involved in solving real world problems using statistics with a view to improving such problem solving.

Reading contexts emerge in everyday situations in which people see and interpret graphs (e.g. watching TV, reading newspapers, looking at advertisements while shopping, visiting internet sites etc). *Reading contexts* are related to situations in which people are interacting with 'media' or 'mass communication' which is

associated with social vehicles of communication such as: radio, television, and print publications with large number of copies.

Although Gal (2002) differentiated these types of contexts (*enquiry* and *reading*), each context is not homogenously defined because individuals can develop different types of participation. For example, people engaged in a *reading* context can be actors, speakers, writers, readers, listeners, or viewers, in either passive or active roles. Gal also argues that the same person might be both a reader and/or a data producer, depending on their engagement in certain context.

Other important contexts in which interpretations of graphs are developed are *school contexts* (Monteiro and Ainley, 2003a). In these contexts the interpretations acquire specific characteristics which make them different from *enquiry* and *reading contexts*. Chapter 3 (section 3.4) presents some issues associated with the interpretations of graphs which originally come from print media (*reading* context) in *school contexts*.

Several authors have investigated *computer based contexts* of interpretation of graphs (e.g. Ainley, 1996; Goldenberg, 1987; Gomes Ferreira, 1997; Pratt, 1994, 1995; Santos and Gitirana, 1999; Santos and Pedro, 2000). Although I cannot discuss in detail the findings from these studies due to lack of space. I recognise the importance of aspects discussed by the authors. For example, Ainley (2001) examines different models for thinking about the role of computer in mathematics classrooms. She suggests that in certain *school contexts* the use of graphs might support interactive processes of teaching about graphing in which the learners have more autonomy to approach the graphical representations and the data displayed.

2.9 Teacher education and teaching graphing

Carvalho (2001) states that the interest of statisticians for education began in the 1950's. Statistics became an important instrument composed of rigorous mathematical notions and techniques which can be applied for many situations in different areas. Carvalho emphasises that this instrumental view was reflected in statistics teaching

which emphasised a mechanistic application of formal knowledge of statistics. In the 1970's and 1980's statistics began to be viewed as process rather than a standard range of procedures. In addition, exploratory approaches to data analysis were introduced. This notion of statistics emphasised the importance of statistics as social knowledge (Biehler, 1989).

In the 1980's and 1990's many countries introduced statistics and probability as topics of mathematical curricula of primary and secondary school levels, including the teaching of graphing skills [e.g. England and Wales by National Curriculum (DES, 1989); and Brazil by Parâmetros Curriculares Nacionais (Brasil, 1997)]. The introduction of statistics in primary school was influenced by a movement to reform the school curricula in the 1990's (Moore, 1997a, 1997b; Carvalho, 2001).

Despite official inclusion, in some countries the teaching of graphing has been slow to develop, and ideal teaching about graphing is not yet a reality in most *school* contexts. Ainley (2000c) claims that in conventional classroom settings the teaching of graphing is broken down in a succession of tasks which relate to several sub-skills, such as scaling, drawing axes and plotting points. In addition, in some countries teachers have precarious personal knowledge about graphing. For example, in a previous study I investigated the interpretation of media graphs among Brazilian primary school teachers (Monteiro and Selva, 2001). The data analyses revealed that some of the participants did know basic notions related to graphs. During the interview all teachers recognised the need to learn more about graphing. Most of them gave as a reason for this situation the absence of specific studies in this topic during pre-service or in-service teaching education programs.

Hadjidemetriou and Williams (2001b) investigated teachers' awareness of pupils' graphical thinking. The analysis of semi-structured interviews revealed that some teachers harbour misconceptions themselves, revealing some weaknesses in aspects of the Cartesian graphs of functions (e.g. linearity prototype). During the interviews teachers mentioned very few common errors or misconceptions of the interpretation of graphs, instead the teachers focussed on technical or algebraic

misconceptions. Hadjidemetriou and Williams (2002b) also identify some "mismatch of the teacher's perception of difficulty and the student's actual difficulty, with teachers underestimating technical aspects of graphing and overestimating the difficulty of the interpretative" (p.63).

It would be simplistic to make general statements which emphasise only one factor, such as the assertion that previous experiences which teachers had in a specific knowledge area might directly influence their teaching approaches in that particular area, because teacher education is complex process that involves numerous specific variables (e.g. Becker & Selter, 1996; Monteiro and Pinto, 2004). However, pre-service courses might support better teaching approaches for primary school teachers when they provide a wider range of opportunities for learning different aspects of mathematical content (Adler, 2000), and an understanding of 'recontextualisation' of these contents when teachers move from a teacher education course into classroom teaching.

Teacher education should provide opportunities in which teachers can learn how to approach graphing in ways which should be meaningful and purposeful for students (Ainley, Pratt, and Nardi, 2001). Teachers should know how to legitimise students' directions of enquiry, redirect their attention, encourage certain initiatives and discourage others; provoke meaningful negotiation, maintain proper articulation of activities and conceptual matters (Ben-Zvi & Arcavi, 2001; Nemirovsky & Tierney, 2001; diSessa et al., 1991). Teachers should develop skills to guide the pedagogical setting towards situations in which statistically relevant aspects are discussed, such as questions related to the critical analysis of data or the necessity for the generation of new and useful information (Ainley, 2001; McClain & Cobb, 2001). In addition, teacher education should approach issues which produce important challenges of whether and how to be explicit about mathematical purposes in relation to a resource-based task, and thus about where meanings need to be located to facilitate sense-making, access, and success in school mathematics practice (Adler, 2000).

Finally, teacher education and teaching about graphing should contemplate the relationships which mathematics education has with other areas of knowledge (Wallman, 1993; Boavida, Gomes & Machado, 2002).

2.10 Summary of chapter 2

- Graphs are resources to display data which has a historical development linked with mathematics, statistics and socio-cultural aspects related to the contexts of use along the history.
- Although it can be considered a number of components and types of graphs, it is important to emphasise that a graph is more than the sum of its parts (Kosslyn, 1994) because the visualisation of a graph is not only related to what comes "within sight", but it is also associated with what readers are unable to see (Arcavi, 2003).
- Therefore, it needs to consider the components of graphs and the process of interpretation as well as the readers.
- The review of literature which investigated the elements and processes related to the interpretation of graphs revealed aspects such as:
    - A lack of empirical evidence about the interpretation of media graphs;
    - Many studies emphasised the errors and misconceptions related to the interpretations of graphs;
    - The interpretations of graphs has been investigated in relation to several others factors.
- *Statistical Literacy* refers to a wide range of cognitive and non-cognitive elements which enable citizens to read and understand statistics, and therefore interpret graphs.
- The contexts of interpretation have been emphasised for several authors. This study approaches the context of interpretation of graphs as wider range of elements related to the readers' actions rather than only the graph itself.

- This study highlights four main context of interpretation of graphs: *enquiry*, *reading*, *school*, and *computer based.*
- The development of statistics education and the introduction of interpretation of graphs as curriculum topic is relatively recent.
- Despite the crucial role which teachers play in teaching graphing only a few studies approached the teachers' knowledge of interpretation of graphs.

Chapter 3

Approaching the complexity of interpretation of media graphs

3.1 Overview

In this chapter I discuss several studies which seem to directly contribute to the construction of the idea of *critical sense* in the interpretation of media graphs. These studies approach different aspects which are associated with the complexity of interpretation of graphs.

Initially I introduce the conceptualisation of the graph as socio-cultural mediator (section 3.2). I also present some studies which emphasise the interaction as an important dimension in the interpretation of graphs (section 3.3).

In section 3.4 I discuss the conceptualisation of "everyday knowledge", the nature of "real world knowledge" in mathematics education, and the possibilities of bridging gaps between *out-of-school knowledge* and *everyday knowledge* about mathematics. The discussion of these theoretical elements helps the clarification of aspects related to the nature of media graphs and processes associated with their use.

The following sections present studies which contribute to identifying different elements and dimensions associated with *critical sense* in the interpretation of media graphs. Section 3.5 discusses studies associated with *critical thinking* and *critical education*, and section 3.7 examines studies which explore the affective aspects in mathematics education in general, and in the interpretation of graphs in particular.

Finally section 3.7 summarises the literature review presented in this chapter.

3.2 Socio-cultural aspects of the interpretations of graphs

In chapter 2 I discussed several research studies which approached the interpretation of graphs based on various epistemological and theoretical perspectives about development, learning and teaching. For example, Wavering (1989) and Berg and

Philips (1994) investigate a logical model, the construction and interpretation of Cartesian line graphs based on the Piagetian perspective. Watson and Callingham (2003) base their studies on a cognitive framework (Biggs and Collins, 1991) which provides a structural hierarchy for statistical thinking.

Lajoie, Jocobs, and Lavigne (1995) emphasise the importance in identifying theoretical perspectives of cognitive development which are related to studies in statistics education. According to these authors, it helps to understand the antagonist perspectives such as those which are pessimistic about the role of teaching which changes the statistical misconceptions presented by adults (e.g. Kahneman and Tversky, 1973), and those which are entirely optimistic arguing that students have statistical skills in place and ready irrespective of their age or grade (e.g. Konold, 1991).

In this present study my view of human development is related to the perspective of Vygotsky (1978) who approaches the dynamic of historical and social context with which people interact in course of their development.

Wells (2000) identifies a key feature of Vygotsky's theory: the mutually constitutive relationship between individuals and the society of which they are members. According to Wells from the Vygotskian perspective a society is viewed as a set of overlapping activity systems with their associated communities of practice that produce and reproduce the conditions of human existence.

The socio-cultural theory of Vygotsky particularly emphasises the use of mediators which amplify the possibilities of transformation of nature by humans (Lerman, 1996). These mediators are similar to tools, and there are two main types: 'technology' and 'semiotic symbols'. Technologies are 'external tools' which might modify and enrich human activities. On the other hand, 'semiotic symbols' are tools which mediate psychological processes (e.g. memory, comparison, description, choice, communication etc). The human activities mediated by tools provide a complex transformation of interpersonal cognitive activity into intrapersonal processes (Vygotsky, 1978).

The interpretation of graphs can be viewed as a mediated human activity in which individuals use graphs to communicate data. Graphs as mediators should be understood in relation to the socio-cultural context in which they are used (such as the types of contexts which are introduced in section 2.8 of chapter 2), and aspects related to the historical genesis and development of this mediator (such aspects of the history of graphs which are discussed in section 2.2 of chapter 2). The phenomenon of interpretation needs to be understood in micro-dimension (e.g. when a person interprets a media graph he/she is doing so as an individual) and in a wider social dimension (e.g. a media graph is a type of mediator which is developed by the society in which the reader participates).

Although I cannot discuss in detail the main aspects of Vygotsky's theory due to the lack of space, I would like to emphasise that this socio-cultural perspective offers important elements, which can contribute to understanding the graph and its interpretation. For example, the idea of mediator is related to interactive processes which people can engage in when they are interpreting graphs. In following section I discuss research which particularly approaches aspects of this interactive dimension.

3.3 Interpretation of graphs as an interactive process

Several studies have explored the relationship between the graph and the person who interprets it. For example, as mentioned in subsection 2.7.3, diSessa, Hammer, Sherin & Kolpakowski (1991) emphasise that the understanding of the interpretations of graphs in *school contexts* should be based on what is 'proposed' by the teacher, 'perceived' by pupils, and 'negotiated' by the class group.

Lajoie, Jocobs, and Lavigne (1995) discuss studies which approach statistics and mathematics teaching and learning in an *active* away. These authors highlight the fact that active approaches which treat statistics as an ill-structured discipline, where there is more than one right answer, can open the doors to alternative forms of teaching and learning that emphasise the constructive, *active* nature of learning rather than the traditional receptive view. In particular, Lajoie, Jocobs, and Lavigne state

that these approaches reinforce the active nature of learning statistics which involves opportunities to enquire, investigate, analyse, and interpret rather than to compute and memorize.

Another perspective of the interactive process of interpretation of graphs is developed by Pratt (1994, 1995) who terms *active graphing* as a particular pedagogical approach which is explicitly designed to engage children in the use of graphs to make decisions in an ongoing experiment. The *active graphing* approach emphasises that the process of learning and teaching graphing involves several factors such as: children's everyday informal intuitions and the tools and resources available (Ainley, Pratt & Nardi, 2001).

Several authors discuss the notion of *transparency* as another important theoretical idea related to the interative processes of interpretation of mathematical representations such as graphs (Adler, 1999; Ainley, 2000b, 2000c; Lave and Wenger, 1991; Meira, 1998). Ainley states that the increasingly widespread use of graphs of many kinds in advertising and the news media for communication seems to be based on an assumption that graphs are transparent in communicating their meanings. The transparency is conceptualised as being inherent in the graph itself. In contrast to this perspective, Ainley argues that a graph may be considered as transparent for a particular user if it is both visible to reading, and invisible in giving access to features of the phenomenon it represents. Therefore, the transparency of graphs is not an inherent feature of the resource, but rather a function of its use in practice in certain contexts. For example, when readers engage in a meaningful situation of interpretation they can use graphs to imagine ways of travelling through a symbolic space where events and narratives unfold (Carraher, Schliemann and Nemirovsky, 1995).

Lave and Wenger (1991) and Meira (1998) suggest that the notion of transparency can illuminate classroom processes because both visibility and invisibility are part of transparency in the practice of teaching mathematics. Resources need to be visible to be used. They also need to be invisible to illuminate aspects of

learner meanings and classroom processes. Adler (1999) also argues that the conceptualisation of transparency of resources might support dynamic pedagogic practices both in the mathematics classroom and in mathematics teacher education.

The media graphs as resources have specificities which need to be considered in order to discuss the dynamic process of interpretation. In the following section I introduce some of these issues.

3.4 Interpretation of media graphs in out-of-school and school contexts

As discussed in section 2.8 of chapter 2, interpretations of graphs might be considered an academic activity for certain professionals who participate in *enquiry contexts*. However, the interpretations developed by people who engage in *reading contexts* have different characterisation. In this section I discuss some issues associated with the differences between *school* and *out-of-school contexts* in order to clarify the nature of the interpretation of media graphs and their implications for the research situations developed in this study.

Several authors term as *everyday* the use of mathematical knowledge in *out-of-school* practices (e.g. Lave, 1988, 1997; Noss, Hoyles, and Pozzi, 2002; Nunes, Carraher and Schliemann, 1993; Säljö and Wyndhamn, 1990; Saxe, 1991, 2002). Lave (1988) argues that the label 'everyday' is heavily associated with a negative connotation which is contrary to scientific thought. According to this author the term is used to humble domestic activities and their associated social rules. People frequently associate everyday knowledge with a less complex type of knowledge which might be called 'informal' or 'non-systematic'. However, Lave, Smith, and Butler (1989) argue that the definition of everyday activity applies directly to *school practices* where children and teachers do mathematics lessons everyday, and go to school on an everyday basis. Lave and her colleagues consider that the everyday practices of mathematics teaching and learning are specialised practices with conventions, occasions, organizations which are not a privileged, value-neutral, or

superior form of social practice. These authors criticised assumptions which approach *school* and *out-of-school practices* as antagonistic.

A similar discussion to the apparent opposition between *out-of-school* and *school knowledge* can be developed with the correlated notions of 'real world', 'real life' or 'realistic'. Generally, this debate leads us to perceive the school as having the status of 'non-real world' (Meira, 1993). However, *school practices* are part of individuals' real lives who are directly involved with schooling (children, parents, teachers, curricular and educational policy makers, researchers etc). These everyday multifaceted relationships between people and schooling make the school part of the 'real world' for individuals.

Therefore, in the present study I recognise that interpretation of media graphs is frequent *out-of-school* activity for readers of media publications. Although I also acknowledge that these reading contexts have particularities, I do not see the interpretation of media graphs as an inferior or less complex mathematical task. My perspective also does not approach the interpretation of media graphs as necessarily being more "real" than *school contexts* of interpretation.

Ainley (2000a) comments that there has been a considerable amount of research in mathematics education into the difficulties which children have in combining *school* and *out-of-school* mathematical knowledge to answer pedagogical tasks. For example, Cooper and Dunne (2000) investigated the 'realistic items' used in a national assessment system, which evaluated children's mathematical knowledge in England. The elaboration of those items was based on the belief that 'relevant' and 'realistic' contents should be a guarantee of the presence of 'real world' in the word problems. Cooper & Dunne particularly discuss graphing items which motivated the children to draw on their *out-of-school knowledge* which actually distracted some pupils from focussing on the "correct" solution to the problem presented. They identify the difficulties which children encounter in answering mathematical questions as arising from the need to understand how much attention should be paid to the situational content of the task.

Watson (1997) suggests that students' poor performance is due to the use of unauthentic *out-of-school* situations inserted in graphing tasks. Watson argues that if evidence of the need for statistical literacy is found in *out-of-school* reading contexts, then the media is also an ideal vehicle to provide initial motivation for the study of statistics, application of specific topics in the curriculum during instruction, and items for assessment in the final stages of learning. This innovative approach tries to make an important link between *school* and *out-of-school* uses of statistical knowledge. However, Watson's approach does not consider a number of factors related to the complexity of the use of media graphs in *school contexts*.

Firstly, it seems that the 'motivation' alone is not a sufficient justification to introduce the use of media graphs in classroom activities. Ainley (2000a) emphasised that the purposeful aspect must be a base for the development of pedagogical tasks:

> *"Children may be motivated by their enjoyment in carrying out a task, or by the novelty of a situation, but still see little purpose in what they are doing. However, the difference in the quality of attention which comes from engaging in a purposeful task is very marked" (p.151).*

Secondly, Adler (2000) emphasises that the use of *out-of-school resources* in and for *school* mathematics involves a process of recontextualisation (Bernstein, 1996) which is complicated and sometimes contradictory. Therefore, the importation of media graphs to *school contexts* needs to consider elements which are associated with their production and use in *out-of-school* contexts.

In this study I see interpretation of media graphs as a process related to both *out-of-school* and *school contexts*. Although, I recognise the complexity related to the use of media graphs in school contexts I believe that the investigation of this activity can provide elements to bridge the gaps between those contexts.

The debate related to the differentiation and relationship between *out-of-school resources* and *contexts* and *school contexts* also involves a very controversial issue: the transferability of knowledge. The notion of transfer is based on the supposed possibility of 'transposition' of knowledge from one situation for another. Therefore,

'transfer' is related to the idea of straightforward 'reproduction' and/or 'generalisation' of an aspect which is learnt in one situation for/in other situations (Saxe, 1991). Important critiques of the concept of transfer have been developed by authors who investigated the learning and teaching processes in specific social practices. For example, Lave (1988) emphasised that the concept of transfer is completely inadequate because it does not consider the socio-cultural situations in which the knowledge is developed. Saxe (1991) re-conceptualised transfer as an extended process of repeated constructions of appropriation and specialisation that emerge again and again in cultural practices.

According to Evans (1999) situated cognition approaches (e.g. Lave, 1988) do not explain why certain knowledge acquired in one setting is or is not triggered, used and useful in another. Evans (2000b) tries to build an alternative approach to explain the fact that an immersion in one practice is and can be generative of, and related to, ways of knowing and being across sites, discourses, and practices. Therefore, Evans re-conceptualises transfer analysing other factors such as the notions of 'near' and 'far' transfer.

In this study, I use the term *mobilisation* (Monteiro and Ainley, 2002, 2003b) related to the possibility of re-using or re-sourcing (Adler, 1999) previous knowledge and experiences during the process of interpretations of media graphs. This *mobilisation* seems to be a process in which readers explore the data, confronting it with their own perspective, and their previous experiences related to the data interpreted. However, the process of *mobilisation* in interpretation of media graphs does not 'naturally' happen. From my previous study (Monteiro, 1998, 2002a) I identified that in order to *mobilise* their previous knowledge and experiences to interpret a media graph, readers need to establish a certain level of engagement in the task, which then leads to the articulation in which they make a recontextualisation of the knowledge and experiences mobilised, comparing them to the data displayed on the graph. Therefore, there is no direct application of knowledge and experiences for the process of interpretation.

The processes and components related to this *mobilisation* seem to be complex, and a number of aspects need to be discussed. For example, as mentioned before in this study, media graphs are used in the discursive context which might emphasise or disguise aspect of the data (e.g. Meira, 1997). Therefore, readers of media graphs should not necessarily accept the ideas suggested by the data displayed. In this context, an ideal role of a *mobilisation* should be to support criticisms about the data interpreted. In order to reflect this particular aspect of the process of interpretation I discuss several studies which might illuminate the critical dimension of the process *mobilisation* during the interpretation of media graphs.

3.5 *Critical thinking* and *critical education*

The term 'critical thinking' was originally used to denominate argumentation involved in processes of reasoning, which was investigated by different theoretical perspectives from different areas, such as: Linguistic, Philosophy, Psychology, Sociology, Epistemology, Education etc (Carraher, 1983).

Thomson (2002) explains that those approaches generally emphasised *critical reasoning* as cognitive human processes which involve the use of verbal language (written or spoken) in different situations of everyday activities, including academic and informal contexts. Thomson states that this kind of approach helps us to identify whether the conclusions which are drawn from the facts or evidence really do follow, both when people themselves are drawing conclusions and when they are assessing the reasoning of others.

McKnight (1990) observes that *critical reasoning* has been researched as general processes involved in the reading of typically non-numerical data to which literate individuals are exposed. McKnight, Kallman and Fischer (1990) argue that little investigation has been done to understand the nature of the ability to think critically in the presence of arguments with essential quantitative elements, such as in the interpretation of graphs.

McKnight and Fisher (1990) investigate aspects of critical reasoning involved in comprehension and use of graphical stimuli in question answering and other practical tests. McKnight (1990) explores the interpretation of graphs that would be encountered either in relatively popular media (e.g. *Scientific American*) or in academic texts and monographs. Some graphs were related to propositions that were patently false (e.g. "storks bring babies") or to others that would seem more likely to be true (e.g. "population will increase faster in developing countries than in developed countries"). Seven participants from academic backgrounds (professors and graduate students) participated in the study, answering multiple-choice and open-ended questions, which were related to a five level taxonomy of information processing tasks:

- *Observation of facts in the graph;*
- *Observation of relationships in the graph(s) as graphs;*
- *Interpretation of relationships in the graph(s) in the "real-world" context;*
- *Evaluation of the value of the graphical data as evidence;*
- *Assessment of the basis on which each subject made his/her evaluation* (pp. 174-183).

The results indicated that only the tasks related to the observation of facts in the graphs seemed to be "unproblematic" (McKnight, 1990, p. 183). A preliminary catalogue of processing errors that occurred emphasises the importance of the reader becoming distracted by extraneous knowledge (McKnight, Kallman and Fischer, 1990):

> *Translation from the 'clean' world of abstract mathematics to the 'messy' world of everyday reality – in which all of our knowledge has links to other knowledge as well as links to personal beliefs and emotional reactions – introduces yet another complexity. Sometimes that other knowledge – or what one thinks is other relevant, linked knowledge – or those beliefs and affective reactions interrupt the more cognitive, information processing tasks of interpreting the graph (p. 14).*

McKnight and her colleagues recognised that the reactions and feelings expressed by readers when they are interpreting media graphs are relevant aspects which need

further investigation. However, it seems that this perspective emphasises these 'everyday' non-mathematical or non-statistical components as causing interference in the interpretive process.

McKnight was interested in assessing individual competencies in the critical evaluation of graphical arguments, and planned her survey procedures according to this rationale. McKnight used a pre-established taxonomy in the assessment of interpretations. This research design seemed to anticipate a "linear sequential order" of development in the interpretation of the graphs, which started from "low levels" characterized for literal interpretations. In addition, although McKnight gave multiple choice items in a "talk-aloud" format in which the participants were audio-taped it is most likely that this experimental approach could restrict the possibilities of interpretation of graphs.

McKnight's and Watson's studies are innovative in investigating the interpretation of media graphs which most people read in everyday situations. However, I argue that they attribute an excessive importance to the graph itself. In particular, they deliberately used 'misleading' media graphs in their experiments and surveys as stimuli which provide the opportunity for a specific type of interpretation. However, misleading aspects are not always visible and even accurate graphs can be misinterpreted in a specific context of interpretation.

However, McKnight and her colleagues make an important contribution to understand the complexity of a *critical* dimension in the interpretation of media graphs. McKnight identifies being *critical* about misleading data as not only related to rational thinking. This seems to be evidence of the ***mobilisation*** of readers' previous knowledge and experiences and is related to a wide range of elements including 'illogical' reactions and feelings about the media graphs interpreted.

In order to continue my discussion of the *critical* elements associated with interpretation of media graphs I review other studies which approach the *critical* dimension in education differently. Those studies are related to *critical education* as a specific approach of *critical theory* (Gibson, 1986) which was developed by several

authors (e.g. Freire, 1972; Giroux, 1983, 1989). This perspective of the *critical* emphasises that education is a process embedded in a complex context of relationships between political, social, economical and cultural factors.

For example, Freire (1972) develops an original concept of *critical consciousness* (from the Brazilian Portuguese "consciência crítica") which is an aspect that each individual should develop to perceive social, political, and economic contradictions, and take action in a conscious and creative manner against the oppressive elements of reality.

Freire (1993) argues that traditional teaching can viewed as *banking education*, because it is very similar to a banking system in which the students are depositories and the teacher is the depositor. Freire (1972) suggests the problem solving situations proposed for *banking education* display a constructed "real world" which is "background" of the problem. This kind of question contributes for the construction of a "false perception of the reality". Therefore, Freire alternatively proposes *problem-posing education* in which teachers and students develop their power to perceive critically the way they exist in the world with which, and in which they find themselves; they come to see the world not as a static reality, but as a reality in process, in transformation. Freire also suggests that *out-of-school resources* (e.g. articles, interviews and graphs from newspaper and magazines) can generate more authentic pedagogical *problem-posing* situations because they are genuine resources from the socio-cultural context in which students participate.

Shaull (1990) states that the Freirian perspective of education emphasises that every human being is capable of looking critically at his/her world in a dialogical encounter with others. Freire (1992) emphasises that education must be based on authentic and conscious dialogue because this kind of communication is also capable of generating critical thinking. Freire claims that the teaching and learning of mathematics which does not consider the social and political aspects involved might be a useful way to disguise the important role of mathematics as social knowledge.

Studies in *critical mathematics education* (e.g. Borba and Skovsmose, 1997; Frankenstein, 1997; and Skovsmose, 1994) are very close to the Freire's perspective. Frankenstein (1998) based their research on the Freirian perspective. She suggests that mathematics should be taught as a tool to interpret and challenge inequities in society. Therefore, an important aim of *critical mathematics education* is to enable teachers and students "to read the world". To accomplish this goal, for example, it is necessary to learn how mathematics skills and concepts can be used to understand why and how a graph is a kind of description of the world. Moreira (2002) also exemplifies a situation in which students experience their *critical consciousness* when interpreting graphs.

Ernest (2000) suggests that *critical mathematics education* adds an aim of the empowerment of the learner through the development of critical mathematical literacy capabilities and the critical appreciation of the mathematics embedded in social and political contexts. Thus the empowered learner will not only be able to pose and solve mathematical questions, but also be able to address important questions relating to the broad range of social uses (and abuses) of mathematics.

The perspectives of *critical education* also influenced studies in statistics education. For example, Vithal (2002) states that the relatively new inclusion of statistics in school curricula has enhanced the opportunity for learners to experience the relevance of this subject for their own lives. She emphasises that teacher education has had to take on challenges such as how best do we prepare teachers to connect mathematics and statistics education to learners' own realities. Vithal believes that teaching of statistical topics such data handling should have a sharp focus on context but be embedded in particular ideological and value orientations which seek to integrate goals of equity, democracy, and social justice.

The theoretical perspectives discussed in this section build a perspective that analyses the interpretation of graphs considering readers as individuals who think and criticise, but also participate in and feel the complexity of their socio-economical-cultural context. Therefore, in section 3.6 I continue the discussion focusing on

studies which approach the affective dimensions of the *critical* process of interpretation of graphs.

3.6 Affective aspects involved in interpretations of graphs

Several authors recognised that the interpretation of graphs is associated with a complex range of elements which include affective aspects related to the reader's interpretation of graphs (e.g. McKnight, 1990; Swatton and Taylor, 1994). However, these authors did not develop other studies which approach the influence of these aspects.

Walkerdine (1988) and Evans (1999) emphasises that the role of affective factors is under-examined in the literature which approaches the boundaries and bridges between *out-of-school* and formal mathematics.

Evans (2000a) classifies studies which investigated learning and teaching mathematics mentioning emotional or affective aspects. A first group of studies view cognitive and 'non-cognitive' factors as separated entities. A second perspective argues for the general inseparability of the intellectual and the affective. These studies also tend to analyse 'non-cognitive' factors such as emotions which are expressed by behaviours, physiological reactions, and visible feelings. According to Evans both the first and second perspectives considered the relationship between cognitive and affective factors in terms of affect 'interfering with' cognition, or sometimes 'supporting' it.

The third type of approach described by Evans is related to Freudian and Lacanian views which conceptualise affect as unconscious processes which are not necessarily observable in any straightforward way. In this third perspective affectivity is a privileged dimension which provides the power for other factors.

Evans proposes a fourth alternative approach which combined both the emphasis of social relations and the power of personal dimension, embracing both culture and emotion in the study of mathematical thinking. This is approach is based on evidence from interviews which explored college students' 'maths life-histories'

(Evans and Tsatsaroni, 1996). The interviews were composed of tasks in which the content might be viewed either as mathematical, or based on *out-of-school practices.* Those tasks also included interpretation of graphs. Evans (2000a) analysing these interviews emphasises that the relationship between mathematical thinking and emotion is specific to the subject's positioning. In some cases, for example, misconceptions and memory failure might be crucial and related to negative emotional charges that are in many cases specific to school mathematics practices. In other examples, bad feelings associated with previous experiences using mathematics *out-of-school* do not seem to have interfered generally with the numerate aspects of performance of participants. In addition, Evans recognises that emotions (e.g. anxiety, confidence, pleasure, dislike or anger) are not necessarily expressed, but 'exhibited' instead.

da Rocha Falcao et al. (2003) argues that even though "affective" and "cognitive" systems can be referred to as distinct, it would be highly productive to overcome this dichotomy in the context of building a new unit of analysis in psychology of mathematics education. This author emphasises that all these aspects should be considered in a dialectical, conjoint approach, according to the theoretical concept of *inclusive separation.*

The relevance of the affective aspect for the process of the interpretation of graphs mentioned but not investigated enough by several authors constitute a challenge for this present study.

This brief discussion of the importance of affective aspects and their "inclusive separation" with other elements involved in the interpretation of graphs have implications for the notion of *critical sense* in interpretation of media graphs. In the next section I summarise the outcomes from the literature review for the development of the key idea of *critical sense* in interpretation of media graphs.

3.7 Summary of chapter 3

- Based on Vygotskyan theoretical ideas, a graph can be conceptualised as a socio-cultural construct which individuals use to mediate interpretation of data. Similarly to other mediators, the graphs are developed in relation to the historical context in which they are used. For example, the popularisation of graphs by media associated with other socio-historical transformations of the use of graphs constitutes important processes related to individuals' interpretation of media graphs.
- The interactive dimension of the processes of interpretation of graphs are emphasised by several authors. Studies discuss the notion of *transparency* as interactive process in which readers can interpret the data *through* the graph.
- The interpretation of media graphs can be viewed as activity which involve a complex relationship between "out-of-school" and "school" knowledge and practices. The discussion is particularly important to develop the idea of *mobilisation* of different knowledge and experiences during the process of interpretation of graphs.
- Studies emphasise the *critical reasoning* involved in interpretation of graphs. Some perspectives are related to critical mathematics education which highlights the sceptical abilities needed to criticise the social use of mathematics which includes the interpretation of media graphs.
- However the interpretation of graphs does not refer only to rational or sceptical elements and processes. A number of studies emphasise that affective components play an important role in the interpretation of graphs.

Chapter 4

Findings of the pilot study

4.1 Overview

This chapter discusses the pilot study which provided empirical data related to the notion of *critical sense* in interpretation of media graphs which, at the beginning of this stage of my research I was conceptualising as an ability to look behind the data and deeply analyse information and its interrelations rather than simply accepting the initial impression given by the graph (Monteiro and Ainley, 2002, 2003a). This pilot study also examined methodological instruments which would be used on a larger scale in the main study, and helped focus the research problem on a specific aspect which assisted in making the study achievable.

As was said in chapter 2, even though several countries have included the teaching of graphing as a curriculum topic in primary schools the teaching of graphing has been slow to develop. The challenge is also related to the way which graphing is taught during conventional pre-service teacher education courses. Therefore, the investigation of the interpretation of graphs among student teachers constitutes a crucial research target which can help to understand this complex process and to make steps to construct pedagogical perspectives that approach the issues related to *critical sense* in teaching about graphing.

This chapter is organised in sections which initially describe and discuss the methods used in the pilot study for data collection method, sampling, and data analysis (sections 4.2 and 4.3), and the contributions from this pilot study for further stages of the research (section 4.4). Finally the section 4.5 presents a summary of this chapter 4.

4.2 Method

The method of the pilot study was based on discussions from the literature review which I was developing at that time. The literature review approached several studies in graphing which presented important gaps. Firstly, most studies investigate the interpretation of graphs among primary and secondary students (e.g. Leinhard, Zaslavsky, and Stein, 1990; Shaughnessy, Garfield, and Greer, 1996). Secondly, very few studies which I reviewed at that time investigated the interpretation of graphs by teachers. In some of them the teachers had a role in the research but it was not the main focus of the study (e.g. diSessa et al., 1991). Thirdly, few pieces of research focused on sceptical and rational dimensions of the interpretation of media graphs (e.g. McKinght, 1990).

These gaps in the literature and my personal interest in work in the teacher education field were important elements of the decision to carry on with investigations completed before my PhD project (e.g. Monteiro and Selva, 2001).

The data collection of the pilot study was conducted during the third term of academic year of 2001-2002 (April-May). The methodological approach is basically qualitative. However a quantitative procedure was used which supported the data analysis of this pilot study.

Generally, the research session with the participants comprised 5 main stages which are presented in Table 4.1 (below).

Table 4.1: Pilot research session with the participants

Parts	Aims	Task
Briefing and questionnaire	Establishment of rapport for the session. Introduction of a practical activity which helped the participant to engage in the research task. Collection of participant's background information. Have informed consent from the participants.	Generic comments related to data collection and the ethical issues (privacy and confidentiality). The participants completed a questionnaire with 9 items.
School subject questions	To introduce the participant to another type of activity that requires speech. Collect more information about the participant's background.	Answer questions about participants' teaching experiences.

Media graph tasks	The core of the session was related to main aim of the session which was to investigate the participants' interpretations of media graphs.	Open questions related to each media graph which composed the tasks.
Final remarks and *Debriefing*	Before the end of section the interviewer asked for any observation, comment or questions which the participant wanted to make. General comments at the end of the session.	Free conversation about the whole session which included comments related to the research purposes, impressions of the situation, and questions about how the data would be used and other general comments not necessarily related to the session

Kvale (1996) calls *briefing* the stage of the session when the participants are introduced to the research situation. According to this author, during this initial phase the participants could have a grasp of the situation before they allowed themselves to talk, exposing knowledge and experiences to a stranger. As a part of this *briefing*, a questionnaire was introduced which is discussed in the subsection 4.2.3. At the end of the initial stage the participants were asked whether or not they agreed with the videotaping procedure for the interview which was the following part of the research session. The subsection 4.2.3 gives further details of this phase. The final stage of the session referred to *debriefing* in which the interviewer asked for any concerns that the participants could have, such as: doubts about the interview's purpose and how it would be used.

The following subsections describe and discuss methodological aspects associated with the pilot study. Subsection 4.2.1 presents consideration of ethical issues involved in this study. The other subsections describe details about the participants (subsection 4.2.2), and the research instruments of data collection: questionnaires (subsection 4.2.3) and interviews (subsections 4.2.4 and 4.2.5).

4.2.1 Ethical considerations

Two important ethical aspects were considered related to the participation of student teachers in this study: informed consent and confidentiality. According to Kvale (1996), informed consent entails informing the research participants about the overall

purpose of the investigation and the main features of the research design, as well as of any possible risks and benefits from the participation in the research project.

In this pilot study the participants were randomly contacted at the university computer centre. They were asked to help the researcher student on a study in mathematics education by giving an interview. At that first moment I did not give much detail about the topic, structure or aims of the research session. I explained that the main element of the interview would be associated with 'material from print media – newspaper and magazines'. The rationale for this procedure is related to the fact that an extensive explanation about the research aims and the tasks would affect the participants' answers. For example, it was considered that the participants could 'prepare' themselves to give certain responses or even unconsciously could be more aware of specific contents during their reading situations before the research session.

As described in Table 4.1, during the research session there were moments when the participants' consent was explicitly asked to carry out some methodological procedure such as videotaping the session. In the debriefing stage the students could ask more questions about the purpose of the study and the use of the data.

The voluntary nature of the interviews was an important component of the informed consent of the student teachers in the pilot study. Cohen and Manion (1994) argue that this element ensures that the participants freely choose to take part (or not) in the research and guarantees that exposure to risks was undertaken knowingly and voluntarily.

The second ethical aspect involved in the method was related to the guarantee of participants' privacy. The anonymity was considered to protect the participants (Cohen and Manion, 1994). The information provided by the student teachers did not reveal their identity because all participants' names for reports from this pilot study were changed. In addition, even though the nature of the data collected does provide many details about the participants the premise of confidentiality was considered.

4.2.2 Participants

The 10 student teachers that took part in the study were from the second year of a British university's undergraduate course and were following different specialisms (Mathematics, Art, Science and English). However, they had all taken a curriculum methods course in primary school mathematics, which included a section on data handling.

Each student suggested a date and time for the research session which lasted approximately 30 minutes, and they were conducted at the same computer centre in which the students were initially contacted.

4.2.3 Questionnaires

It was considered that background data required about the participants would be easily completed by questionnaire items. Therefore the questionnaire comprised questions about gender, age, specialism, and information about the reading activities background which includes the use of computers. A copy of the questionnaire sheet which the participants completed is given in appendix 4.1. Table 4.2 (below) presents the data collected from those questionnaires.

Table 4.2: Age of participants per specialism

Student	Age	Specialism	Readings (frequency)
Beth	19	Mathematics	Daily Mail (2 or 3 times /week)
Ellie	19	Mathematics	Company and Cosmopolitan (every month)
Suzy	20	Mathematics	Ok Magazine; Hello (not very often)
Jackie	21	Mathematics	No
Amanda	20	English	Guardian (Once every 2 weeks)
Ann	20	English	Daily Mail (weekly)
Maria	31	Science	Sun (occasionally)
Laura	20	Science	Times (at home)
Carole	20	Arts	Shape; Zest (Monthly)
Alice	21	Arts	OK (once every 2 weeks) Daily Mail (once a week)

As can be observed in Table 4.2, all the students were female. Most of participants were aged 19 and 20. Four participants were taking mathematics specialism.

Referring to reading background responses, most of participants had regular access to newspapers. A smaller number of students responded that they read magazines aimed at a female audience. Only one student (Maria – Science) declared herself to be subscriber of a periodical (*Child Education*).

This data suggests that the majority of the participants read print media on a regular basis; consequently they might have access to graphs when reading those periodicals.

Other items of the questionnaire asked about students' activities with computers. The aim of these items was to identify possible access to other sources of web media and other graphing situations with which the participants might be regularly engaged.

Two students said that they did not have their own computer. Table 4.3 (below) shows the participants' responses for the other items related to use of computer.

Table 4.3: Frequency of computer use reported by participants

Activity\ Frequency	Daily	Sometimes	Rarely	Blank
Emails	06 (60%)	03 (30%)	01 (10%)	---
Games	---	05 (50%)	05 (50%)	---
Sources	01 (10%)	06 (60%)	01 (10%)	02 (20%)
Chat	01 (10%)	05 (50%)	01 (10%)	03 (30%)
Text editors	05 (50%)	04 (40%)	01 (10%)	---
Graph or table editors	---	09 (90%)	01 (10%)	---

The results presented in Table 4.3 suggest that the most frequent uses are related to editing text and communication by email. The majority of participants occasionally use the computer to search and edit graphs and tables. This indicates that the possibility of access to graphs in websites and graphing activities by specific software was less frequent for those student teachers.

4.2.4 Interviews

Interviews as the research instrument of data collection provide opportunities for the participants to communicate their thoughts during the process. Lajoie, Jocobs, and

Lavigne (1995) highlight the need to give opportunities to students to verbalise how they reached an answer when they solved statistics problems. According to these authors, verbalizations may be more useful than written text and may, in fact, lead to richer articulations of students' knowledge. In addition, the use of interviews can also register aspects of non-verbal communication which is an important aspect of the participants' responses. The consideration of these aspects led me to introduce interviews as an important qualitative instrument of data collection in the pilot study.

The interviews were conducted immediately after the questionnaires. The interviews were recorded using audiotape and video camera. All participants previously agreed with this procedure and there was no apparent intimidation during the interviews. The videotaping provided additional access to nonverbal communication.

Each interview was initiated with two questions associated to the relationship which the participants might have to the teaching of the specialist school subject. It also asked a question about mathematics teaching as well.

- **Which school subject do you prefer to teach? Why?**
- **Which mathematical area do you prefer to teach? Why?**

The rationale of these questions was to continue the process of data collection about the participants' background initiated with the questionnaire's items. It was considered that the oral answer of these two questions could give more flexibility for the participant to express their personal perspective about the subject specialism teaching activities. Table 4.4 (below) displays a summary of the responses given by the participants for the questions about school subject teaching.

Table 4.4: School subject and mathematical topic preferred per student

Student	Subject preferred	Why	Mathematical topic	Why
Beth	Mathematics	My specialism, I have confidence, I know the right and wrong answer	Number	Easier than geometry and seems quicker and can be more fun
Ellie	Mathematics	I am more confident. I know more, more knowledge than others	Data Handling	Because it is more interesting and can be discussed

Suzy	Mathematics	It is my specialist subject, I enjoy it and like children participating	Number	I find it easier, I just prefer it to geometry and measurement
Jackie	Mathematics	I feel more confidence I know that I feel confidence to teach	Number, fractions	There is a lot of work by computer, there is a lot information about it
Amanda	English	It is my specialism I quite like to teach language, try to get enthusiasm	Number	It is quite easy and natural than teaching graphs that need understanding
Ann	English	I find it really interesting, I love games and interaction with children	Data Handling	Can work with different areas, data area, number sense, interpreting
Maria	Science	I enjoy maths, I feel confidence, but I choose science because I have a high level of knowledge	Number	I have got sense and knowledge about it I had difficulties when I was a child
Laura	Science	My specialism, my area of interest, you can decide more yourself	Shape and space, measure	Practical things are much easier to teach to younger children
Carole	Arts	It is my specialism and I enjoy work with the kids	Measurement	Different ways to teach. Children like practical and different things
Alice	Arts	It is my specialism, enjoy teaching children	Multiplication	Use a lot of games, work with the whole class

Table 4.4 suggests that in most of cases the participants were taking the specialism which is related to their favourite school subject. Generally, they justify that answer based on their experience in teaching placements. The most frequent mathematical topic referred was *Number* (40%), and the justification for that was generally associated with the idea that this theme is easier and can be taught with 'fun'. Two students responded that *data handling* was a favourite mathematical area to teach.

These two questions about subject school teaching were a transition for the core of the interview composed for the media graphs questions which are specifically discussed in the next subsections.

4.2.5 Interview media graph tasks[1]

A crucial stage of the pilot study was the search for, analysis and choice of the media graphs which composed the interview. A number of reasons guided this decision process.

It was considered that 'media graphs' should be used in this study. However, as discussed in chapter 2, the conceptualisations of 'graph' and 'media' vary considerably depending on the perspective with which these terms are approached. In this study, 'media graphs' refers to statistical graphs which were originally published by print publications (e.g. newspapers, magazines, periodicals and public reports) that provide news and information for the general public (Monteiro, 1998).

The search for a sample of media graphs was carried out through several publications from 2001-2002. It was expected that media graphs published in a recent period would be closer to those graphs which probably could be part of participants' readings. It was also anticipated that the topics associated with the graphs should be related to possible participants' everyday interests.

Another criterion considered related to the types of graph which are frequently published in print media. Lima (1998) stated that the two most frequent types of graph in main Brazilian magazines are bar charts and line graphs[2]. The research conducted to choose the media graph tasks indicated a similar tendency in the British media which frequently presents bar and line graphs. Therefore it was these types of graph which were chosen for the research tasks.

In summary, after the process of search and analysis of several examples, three main reasons made me decide on the media graphs used in the research tasks. Firstly, these graphs seem to present accessible levels of complex mathematical relationships

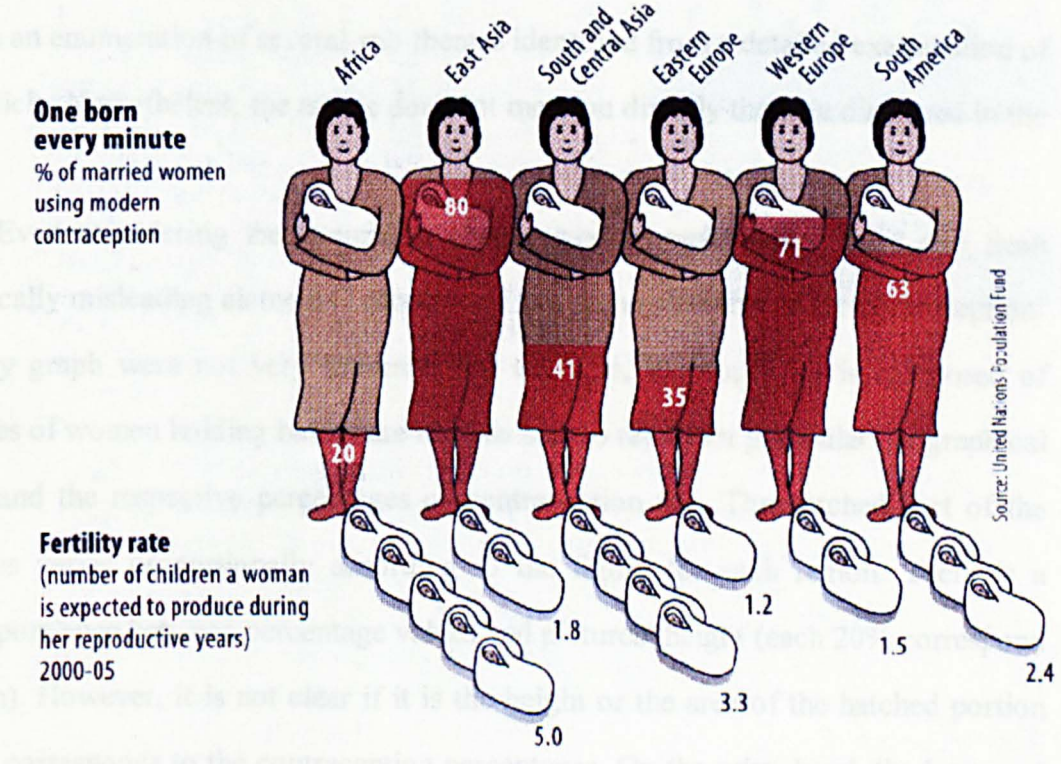
[1] Part of this discussion was published in the Proceedings of 3rd Conference of the European Society for Research in Mathematics Education (Monteiro and Ainley, 2003a).

[2] Lima (1998) analysed the frequency of graphs in the most popular Brazilian weekly news reports magazine between January and November of 1995. Among 157 graphs published 63% were bar graphs and 29% were line graphs.

and concepts. Basically, the graphs are pictograms, bar charts and line graphs which present absolute, rational numbers, or percentages. Secondly, an attempt was made to choose media graphs which were free from technical errors or misleading elements. Thirdly, I chose graphs whose themes were expected to be related to the interests of the participants, all female student teachers living and studying in or near Warwickshire.

When the media graphs were chosen, further analyses were developed to investigate in more detail the data displayed on the graph. The following subsections (4.2.5.1 and 4.2.5.2) are associated with this methodological procedure, and the further subsections (4.2.5.3 and 4.2.5.4) describe the media graph tasks used for the interviews.

Figure 4.1: Graph reprinted from *The World in 2002, The Economist, 2001, p.132*



4.2.5.1 Contraception-fertility graph

The first media graph presented to the students was related to 'contraception use' and 'fertility rates' in different parts of the world. Figure 4.1 (above) is a copy of the contraception-fertility graph which composed the interview task. This graph is a

pictogram in which bars represented women and babies. This represents another characteristic of media graphs which are frequently associated with pictorial elements which illustrate aspects of the data displayed (Meira, 1997; Monteiro, 1998; Monteiro and Selva, 2001).

This graph was originally published in the ***The World in 2002*** which is an annual issue of a well known British magazine *The Economist*. This magazine had several sections which focused on analyses and prediction for the political, social and economical events and facts which were going to happen in 2002. That issue had a worldwide circulation and was read in 90 countries and 14 different languages.

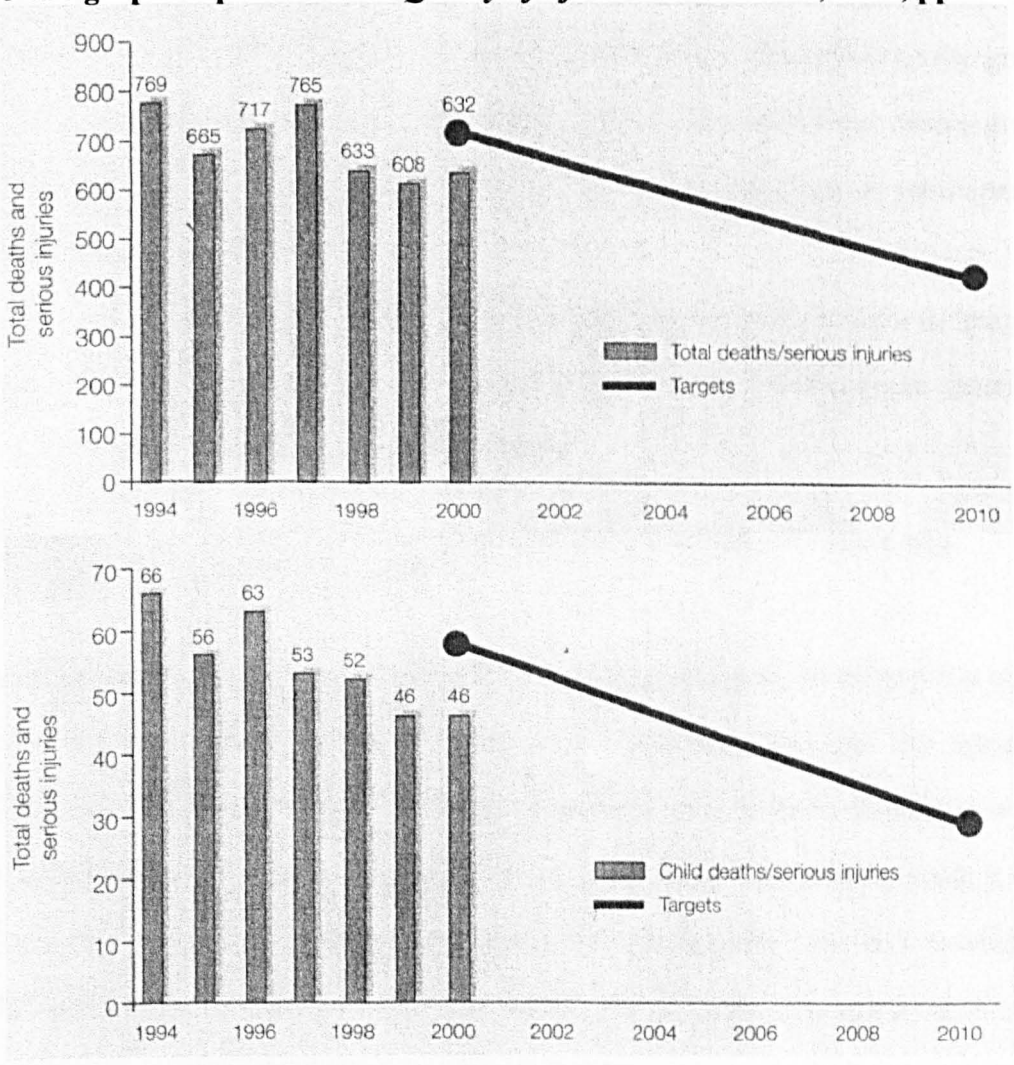
The graph selected was published in the article titled *Fertility rights* (El Feki, 2001) which comprised the last section called *Science and Technology*. Appendix 4.2 shows the magazine page (copy) in which the graph was published. Appendix 4.3 shows an enumeration of several sub-themes identified from a detailed examination of the article. Nevertheless, the article does not mention directly the data displayed in the graph.

Even considering the attempt to choose media graphs which were free from technically misleading elements I recognized that some elements of the contraception-fertility graph were not very accurate. For example, the upper set is composed of pictures of women holding babies are used as bars to represent particular geographical areas and the respective percentages of contraception use. The hatched part of the pictures varies proportionally according to the figure for each region. There is a correspondence between percentage values and pictures' height (each 20% correspond to 1cm). However, it is not clear if it is the height or the area of the hatched portion which corresponds to the contraception percentages. On the other hand, the lower set of fertility rates are presented by pictures of babies. The number of babies pictured is related to the birth rate. However, the correspondence between the number of babies and the rate represented does not follow a proportional relationship. For example, on the graph two babies represent 1.8 as well as 1.5, and one baby represents 1.2.

4.2.5.2 Road accidents graphs

The second and third graphs were reprinted from an annual report called *Quality of life in Warwickshire* (Warwickshire County Council, 2001), that includes economic, social, and environmental indicators. Figure 4.2 (below) presents the two graphs showing respectively the total number of casualties and number of child casualties involved in road accidents in Warwickshire.

Figure 4.2: graphs reprinted from *Quality of life in Warwickshire*, 2001, pp. 93-94.



Some particularities were also identified associated with these graphs. Firstly, the surrounding text in which the graph was published mentions that Central Government in March 2000 expected a 40% reduction in the number of people killed or seriously injured in road accidents. However, neither the written text nor the graph mentions an intended figure (about 379 casualties) for the end of the target period (2010). This

omission does not allow an accurate comparison between the actual figures (2000) and the planned results for 2010. Secondly, the graph does not refer to the data sources on which it is based (Warwickshire County Council for the actual numbers of deaths and serious injuries, and national government for the projected targets).

4.2.5.3 contraception-fertility graph items

Initially, I asked each participant if she had seen that specific issue of magazine *The Economist*. All participants responded that they had not seen this article or the graph before. Immediately after this first question I showed a copy of the media graph printed on an A4 sheet. The rationale of this procedure was to focus the participants' attention on the graph itself.

After they observed the graph for a while, each student was invited to imagine that they could talk to the person who had produced the graph and ask any questions about it. For that, I asked the following question:

> **If you could talk to the person that produced this graph, are there any questions you would like to ask?**

The rationale for this open question was to invite the participants to carry out a wider interpretation of the media graph. For example, it was expected that this question could suggest a reading of the data displayed as well as a reflection about how the graph was produced and what the purpose of the graph was. On the other hand, it was predicted that this question would not direct the participants' answers towards a specific nuance of the process of interpretation. For instance, the question did not emphasise only mathematical aspects. Therefore there were no explicit restrictions for the range of previous knowledge and experiences which the participants could use to interpret the graph.

The question also indirectly invited the participant to have a sceptical attitude by questioning the graph's producer. In summary, it was anticipated that this question

would serve to reach the aim of this pilot study which was to explore the components that constitute *critical sense* in the interpretation of graphs.

After they formulated their comments and questions about the contraception-fertility graph another question was asked.

Is this graph clear for you?

The aim of this question was to provide another opportunity for comments about the interpretation of the graph.

The participants' responses for the contraception-fertility graph are presented in subsection 4.3.1.

4.2.5.4 Road accidents graphs items

The road accident graphs were presented on a photocopy of the page from the actual report. The rationale for this procedure was to identify if any information from the surrounding written texts could be used to interpret the data. As with the contraception-fertility graph the students were invited to imagine that they could talk to the person who had produced the road accidents graphs and ask any questions about it. The students were then asked to consider the possibility of combining data from both graphs to produce one graph. In addition, they were required to think about how realistic the targets displayed in the both graphs were.

1. **If you could talk to the person that produced this graph, are there any questions you would like to ask?**
2. **If the information from these two graphs were combined what would the graph look like?**
3. **Do you think that these targets are realistic?**

The rationale for the two further items was to offer an opportunity to the students to interpret specific elements of the graph. Firstly, the student could approach more directly the two road accidents graphs considering the combination because they needed to draw a graph. I expected that this graphing action would provide a chance

to consider mathematical aspects of the graphical representation (e.g. the use of the scale). Secondly, it was anticipated that the item which asked about the targets would guide attention towards the reasonableness of the data displayed on the graph. I anticipated that these items could provide evidence of comments related to technical aspects (e.g. the use of scales) and informal interpretation (e.g. judgement of the targets) of the graphs. Therefore, I could identify the use of elements of participants' *critical sense*.

In the following section I present and discuss the participants' answers for the questions formulated about the media graphs.

4.3 Analysis of the responses of media graph tasks

An initial aspect analysed from the participants' responses was the frequencies of questions produced for each media graphs' items which is presented in Table 4.5 (below).

Table 4.5: Questions asked per student for each media graph task

Student - Specialism	No. questions for contracept-fertility	No. questions for questions for road
Beth – Mathematics	11	10
Ellie – Mathematics	02	08
Suzy – Mathematics	02	03
Jackie – Mathematics	05	07
Amanda – English	05	06
Ann – English	03	01
Maria – Science	02	01
Laura – Science	04	01
Carole – Arts	02	05
Alice - Arts	09	08
TOTAL	**45**	**50**

I initially expected that students taking Mathematics and Science would have different technical knowledge which might cause their performance to differ from those taking English and Arts. However, the frequencies of the number of questions asked about

the media graphs suggest that the responses of each student do not seem to be related to their academic background.

Other categorisations of the content of questions were produced. Those analyses suggest peculiarities among the questions formulated for the two media graph tasks. The following subsections discuss some aspects of the categories produced.

4.3.1 Contraception-fertility graph items

The contraception-fertility graph was comprised of two data sets related to two different variables. A classification of the participants' questions referred to the dataset (contraception or fertility) which those questions are related to (see Table 4.6 below). This was an attempt to identify predominance of any variable or dataset on the participants' interpretations.

Table 4.6: Classification informing which data setting the questions was related

Setting(s) related	Number of questions	Percentage
General question related to both settings	36	80%
Contraception dataset	05	11%
Fertility dataset	04	9%
TOTAL	**45**	**100%**

The findings presented in Table 4.6 suggest that the majority of students did not emphasise a particular data set. The majority of questions asked about the graph as whole.

"Is he talking about the whole population or just a sample?"[3] *(Ellie – Mathematics)*

Some of questions asked explicitly about aspects of one particular dataset.

"Did they mark every single or married women using modern contraception?" (Jackie - Mathematics).

"Why is this rate 2.1?" (Laura –Science)

[3] During the interviews the participants asked the questions as well making comments. In this chapter most of the examples of questioning do not include the participants' comments.

Another aspect of the contraception-fertility graph's questions which was analysed refers to the main aspect focused by the question. In general, participants' questions regarding the contraception-fertility graph focused on technical aspects of production of data or the purpose of the graph, rather than the topic and data itself. For example, only one question was associated with the relationship between the use of contraception for women and rates of fertility in the regions shown by the graph; and one question asked why only data on married women was included. Table 4.7 indicates the frequencies of questions produced for each category.

Table 4.7: Classification of the questions about contraception-fertility graph

The main focus of the questions	Frequency	Percentage
Questioning the data collection, sample or variables	21	47%
Questioning the purpose of the graph	15	33%
Asking for complementary data	05	11%
Questioning the graph's features (including scale and picture)	04	9%
TOTAL	45	100%

Table 4.7 presents a large percentage of questions concerning technical aspects related to the data, such as: the source of data, and the methodology used to collect it.

> *"Yeah – I'd like to know how they got the pictures in the first place. (...) I'd like to ask about, how they did the survey (...)[4] the actual survey itself. Did they test a small concentrated group? How did they make sure it wasn't varied? Can't see it from the graph (...)" (Anne - English)*

Another frequent category of question was related to the purposes of the graph.

> *"What are they trying to say?" (Amanda –English)*

> *"What's his purpose in making this graph?" (Beth – Mathematics)*

Some questions asked for more information related to the graph's topic

> *"How about the single ones [women][5]?" (Jackie – Mathematics)*

[4] The use of ellipsis in brackets *(...)* means that a small part of the participant's speech was omitted because it repeated what she said immediately before.

[5] The term in square brackets refers to a complementary term which I added to clarify the question.

"He's linking the two, so what's the fertility rate got to do with the number of women using contraception?" (Beth – Mathematics)

Finally, a few questions were related to 'the features of the graph'.

"Why this scale? What scale is that?" (Maria –Science)

As a motivation for final comments or questions about the contraception-fertility graph, I asked each participant to say if that graph was clear for her. The frequencies of answers are shown in Table 4.8 (below).

Table 4.8: How clear is the contraception-fertility graph?

Answer	Frequency	Percentage
No, it is not clear	04	40%
Yes, but it should be clearer	04	40%
Yes, it is clear	02	20%
TOTAL	**10**	**100%**

The results related to the question concerning how clear the contraception-fertility graph was indicated a slight prevalence of positive answers. However, the majority of students who answered positively emphasised that to be interpreted the media graph demands a certain level of attention.

"It is if you look at it quickly. The women give a visually impact but I am not happy with the babies on the bottom. (Maria – Science)

"It is but you need to work out the contraception control..." [6] (Ellie – Mathematics)

4.3.2 Road accidents graphs items

The frequency of questions about the road accidents graphs was similar to the frequency of questions about the contraception-fertility graph (see Table 4.5). However, Table 4.9 (below) suggests that the participants produced a greater variability of questions for road accidents graphs tasks than for contraception-fertility (compare with Table 4.7).

[6] There are two different meanings for ellipsis ... in the transcripts quotations of this thesis: it can mean that the sentence was not started or finished properly, or it indicates that the participant gave a pause when formulating a sentence. In this case, it means that she did not finish the sentence properly.

Table 4.9: Classification of the questions about road accidents graphs

Main focus of the questions	Frequency	Percentage
Questioning the targets (e.g. how they were planned)	17	34%
Questioning the data collection or sample size	12	24%
Concepts involved (deaths, child and serious injury)	08	16%
Questioning graph features	06	12%
Questioning purpose of graph	04	8%
Questioning causes of accidents or decrease	03	6%
TOTAL	**50**	**100%**

The most frequent category of question asked about the targets displayed in the graph. The participants' comments during the interpretation of the road accident graphs were not restricted to technical aspects but they involved questioning about the contexts in which the targets were planned.

"How did you work out the actual targets for 2010?" (Ann – English)

"What they are going to do to reach the targets?" (Carole –Arts)

Another frequent category referred to questions related to data collection or sampling.

"Where did they get this information?" (Alice – Arts)

Some of the questions asked about the conceptualisation of certain terms used in the graph.

"As I was saying, what's serious injury? What's classed as serious injuries? And what age do they class as children?" (Jackie - Mathematics)

There were few questions about the purpose of the graphs.

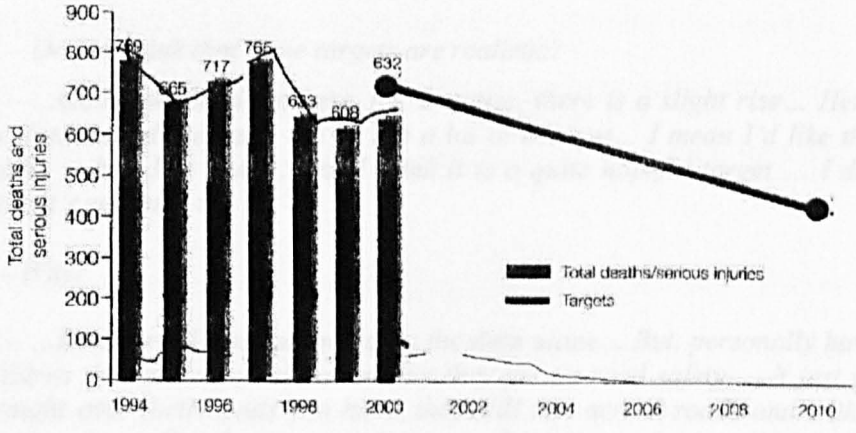
"What the purpose of the graph?" (Amanda –English)

Finally, few questions were asking for more information related to the graph's topic

"What was involved in these accidents: cars involved; drunken driving, etc?" (Beth – Mathematics)

In the road accidents graphs task, the participants were also invited to compare and combine the data that came from both graphs[7]. This necessitated that they (at least visually) manipulated data. The manually drawn graphs produced by the students were an important resource for them in beginning to establish relationships between the data. For example, Carole (Art) drew a line joining the tops of the bars on the first graph (See Figure 4.3 below), and then added a line to represent the tops of the bars for the children's graph below this.

Figure 4.3: Carol's response for the second item



"I think I'd probably do line graphs more like these ones. Because... then it would be like you would use that scale and then it would be easier to show that children are quite a lot less than... I'd have a line joining like these up to show... and then I'd have like the children's ones like down here (drawing on the copy) showing the difference between them... so that there would be a line for those. Probably have to use a different scale like that... And then the targets...then... I'd keep probably keep the same, but not obviously not join the lines... and then you could see the child's target down here. But by doing like that, you're saying that you could compare them more easily. Suppose that when they're on the same graph it would be easier to compare it."

Finally, the student teachers interviewed were asked whether the targets shown on the graphs were realistic. Table 4.10 (below) shows the frequencies of answer for that specific item.

[7] Part of this discussion was published in Monteiro and Ainley (2003a).

Table 4.10: Are the targets realistic?

Answer	Frequency	Percentage
No, they are not realistic	04	40%
Yes, but it depends on certain measures	03	30%
Probably yes	02	20%
Did not answer	01	10%
TOTAL	**10**	**100%**

Different interpretations were given based on the same information. Generally, these considered contextual factors were not displayed on the graph. For instance, Maria (Science) referred to the continual rise in the amount of traffic, which was not taken into account by the graph:

> *R[8] – Do you think that these targets are realistic?*
>
> *M – ...Going on the data there, no. Because, there is a slight rise... Here... the data stayed the same but ... it's a lot to achieve... I mean I'd like those deaths reduce like much... but I think it is a quite hopeful target ... I don't think it's realistic, no.*
>
> *R – Why?*
>
> *M – ...Because if I was just going on the data alone... But, personally having children the amount of education that they get on road safety ... it just goes straight over their heads you know they still run across roads and with the increase in traffic, the increase in cars... I can't see the correlation of an increase in traffic and the reduction in road accidents, but... That's personally me...*

I inferred that Maria considered the data displayed but also responded based on experience as a citizen and mother. Although Maria recognised some measures to prevent road accidents she also considered examples from her social context. Therefore, Maria's interpretation involved cognitive (e.g. she analysed the trends of graph) and non-cognitive aspects (e.g. she hoped to see the figures decreasing but she believed that children did not behave safely on roads). Maria developed a process of interpretation which *mobilised* several elements related to her mathematical knowledge and previous experiences. She also seemed to *balance* such elements in

[8] The extracts which start with R are associated with the researcher's speech. The others start with the initial letter of participant's names (e.g. M = Maria).

order to respond the question. I inferred that these elements of Maria's interview were related to the process of *critical sense* of her interpretation.

4.3.3 Discussion of the interview tasks[9]

The interviews in this pilot study were not simply opportunities for data collection, but situations in which learning and teaching happened for myself as researcher, and for the participants engaged in a problem solving activity.

In general, the comments of most of the students were more limited during the interpretation of the contraception-fertility graph than in the task using the road accidents graphs. In addition, the higher variety of the types of questions related to the road accidents graphs is another indication of the difference between the approaches developed for each media graph task. When students were interpreting the road accident graphs they drew on a range of elements related to their previous knowledge and experiences.

It seemed that during the road accident task, many students were more engaged in the data-handling situation, and they seemed to display a sceptical attitude in relation to the data interpreted. The topic of these graphs was closely linked with the daily lives of the students, particularly as it came from the region in which they study and/or live. The task was also second in the interview, when students were more relaxed. However these arguments seem too simplistic to explain why the students demonstrated more explicitly aspects of *critical sense* in discussing these graphs.

Analysis of the differences between the responses to the two tasks is therefore significant in exploring aspects of the interview tasks, which were important for identifying *critical sense* in the participants' interpretation. A number of factors are considered below.

Firstly, I emphasise the types of media graphs used. The fertility graph is typical of many graphs presented in print media, in that it uses pictorial images related to the

[9] Part of discussion also was published in the Proceedings of the Day Conference of British Society for Research into Learning Mathematics held at Nottingham University (Monteiro and Ainley, 2002).

subject matter. It is essentially a combination of two bar graphs, showing levels of contraception and fertility rates, but the presentation tends to disguise the fact that two different data sets are being offered for comparison. In contrast, the road accident data was displayed on two separate bar graphs, with no decorative material. This invited comparison between the data sets, although the scales were different.

Secondly, I highlight that the initial question asked in both tasks ('*if you could talk to the person who produced this graph, are there any questions you would like to ask?*') was designed to elicit sceptical comment, and also to legitimise such comment and questioning, in contrast to traditional pedagogic settings which are limited to closed reading of graphs.

In the road accidents task, a further question required the students to make judgements about the reasonableness of the targets. The road accidents task required the students to do some simple manipulation in order to produce a graph which combines the two sets of data. This moved them from being simply readers of the graphs towards being more actively involved in data analysis and presentation. Finally, I emphasise the relevance of data content. Although both graphs were chosen because it was considered that the data content would be relevant to the participants (all female student teachers), the road accident data seems to have engaged their interest and concern to a far greater extent than the contraception-fertility data. The limited data available from this pilot study means that I can do no more than speculate about the reasons for this. Engagement in purposeful activity plays an important role in deriving meaning from content and I conjecture that this will support the development of *critical sense* in the participants' interpretation of graphs. The relationship between engagement with data content and the development of critical approaches was an important observation for further investigation in the main study. It does not seem easy, even when considering this factor explicitly, to predict the relevance of data content for particular groups of students.

4.4 Directions for the main study

The pilot study was useful in that it enabled me to analyse a workable methodological approach for use in the main study. Therefore, during the development of the pilot study I could trial several methodological procedures related to the two main research stages:

- Data collection (e.g. choice of instruments of data collection, ways to contact the participants, arrangement of satisfactory material and environment, data recording, informed consent and other ethical issues)

- Data analysis (e.g. choice for methods of data analysis and systematisation of findings).

The evaluation of pilot study procedures allowed me to identify limits and possibilities in applying a similar method to a larger scale study (main study). For example, I considered that the use of the same media graphs with refinements of the tasks could allow comparative analyses of the findings from the pilot and main study.

The questionnaires and interviews seemed to be important research instruments for collecting different types of data related to *critical sense* in interpretation of media graphs. However, my analyses of data collected indicate that it is quite difficult to fit the student teacher's responses into hierarchical classifications (e.g. McKnight, 1990; Watson, 1997).

This pilot study was also the base for my PhD Upgrade proposal which was presented to a committee that gave important feed-back. At that time the committee suggested that the research proposition pointed out three main aspects for investigating the *critical sense* in graphing: the study of *critical sense* as a phenomenon itself, the characteristics of people who display or use *critical sense*, and the pedagogical issues related to *critical sense* in the teaching and learning of graphing. The committee members emphasised that decisions about the methodological approaches of the main study should consider the complexity of the object of study and practical issues related to time and amount of work. Reanalysing

the data generated by the pilot study I decided to focus on the investigation of the notion of *critical sense* as a phenomenon. However, the fact that the participants would be primary school student teachers also included the other two aspects indicated by the upgrade committee: people and pedagogy.

The discussion of the pilot study findings motivated a re-elaboration of the definition of *critical sense* in interpretation of media graphs. For example, it was important to develop a conceptualisation of *critical sense* which was not related solely to a sceptical dimension. The pilot study gave me evidence that *critical sense* involves *mobilisation* and *balance* of several *elements* related to the participants' previous knowledge and experiences.

4.5 Summary of chapter 4

- The pilot study was developed with the participation of 10 British student teachers, all females taking different specialisms (Mathematics, Science, Arts, and English) in the 2nd year of a university undergraduate course.
- This pilot study was based on a qualitative methodological approach which comprised two data collection instruments: questionnaires and interviews.
- During the data collection sessions, questionnaire items and interview questions were used to identify academic, reading and teaching backgrounds of the participants. The media graph tasks were given as part of the interviews.
- The participants did not mention any problematic aspects in relation to mathematics and generally they preferred to teach mathematical topics which had more possibilities of pedagogical activities.
- The contraception-fertility graph task was composed of one item which invited the participants to imagine that they could ask the person who produced the graph questions.

- The road accidents graphs task comprised three items which explicitly requested the use of technical and informal knowledge related to the interpretation of graphs.
- The analysis of the differences between the responses to the two tasks is therefore significant in exploring aspects of the interview tasks, which were important for identifying *critical sense* in the participants' interpretations.
- The pilot study was useful in that it enabled me to analyse a workable methodological approach for use in the main study and helped to focus the investigation on the phenomenon of *critical sense* in interpretation of media graphs.

Chapter 5

Main study method

5.1 Overview

This chapter discusses methodological aspects of the main study in which data collection was carried out during the 2002/2003 academic year. As discussed in chapter 4 the elaboration of the method utilised on this study considered the findings of the pilot study which was conducted during the Summer Term of 2001/2002.

The main study data came from questionnaires and interviews with student teachers from university education courses in Great Britain and Brazil. The research sessions were recorded on audiotape and videotape. The participants' responses from the questionnaires and interviews were coded and categorised utilising NVivo software package.

In section 5.2, I discuss issues related to the definition of main study method. The following section 5.3 presents the main elements related to the participants and the research instruments of data collection. Section 5.4 outlines aspects of the data analysis. Finally, section 5.5 provides a summary of this chapter.

5.2 Defining the methodology

This study explores the notion of *critical sense* in the interpretation of media graphs among student teachers focusing on the identification of the *elements* and *processes* which constitute this phenomenon. The investigation among student teachers highlights another aim of this study which is to explore possible pedagogical implications of *critical sense* in graphing.

The methodological approach of this study is based on two main datasets (questionnaires and interviews) with the purpose of investigating *critical sense* in the interpretation of media graphs.

One dataset is related to quantitative analysis of data from 218 questionnaires given to British and Brazilian participants. Unlike complicated statistical procedures, analysis of the questionnaires involved the counting the participants' responses in order to establish patterns. However, this 'simple counting' of responses depended on qualitative observation which was the basis for the categorisation of the data. The quantitative analysis carried out is related to the approach of Gorard and Taylor (2004) who suggest the combination of simple numeric techniques which describe a larger picture related to the phenomenon investigated, but which are linked to a second dataset which consists of more in-depth data. The second dataset analysed in this study refers to interviews with 13 volunteers.

The combined method developed in this study consists of an attempt to *interplay* between qualitative and quantitative methodological approaches (Strauss and Corbin, 1998). This *interplay* is based on the acknowledgement that each perspective gives a partial picture of *critical sense* in interpretation of graphs. Therefore I anticipated that the large data collection associated with the questionnaire could provide evidence to discuss the *elements* involved in *critical sense* in interpretation of graphs, while the interview data could offer an indication of processes involved.

Another important aspect related to this *interplay* approach refers to the use of the main research instruments of data collection. Therefore, the use of questionnaires and interviews was a complementary approach rather than a mutual validation of data (Gorard and Taylor, 2004). For example, the construction of the interviews was based on the preliminary analysis of the questionnaires. In addition, the interviewees were volunteers who also responded to the questionnaire.

The choice for the method of this study is also based on the discussion of the literature review which indicated the failure of previous studies utilising quantitative methods, such as surveys with multiple choice items (e.g. Curcio, 1987), to approach other elements of interpretation of graphs associated with informal knowledge and previous experience. Even authors who utilised only quantitative methods recognised

that qualitative research methods would give more evidence about the complexity of the interpretation of graphs (e.g. Watson and Callingham, 2003).

5.3 Data collection

Although the methodological approach of the main study proceeded along the same lines as the pilot study, a number of refinements were made. This section presents the main elements of the data collection developed in the main study characterising the participants (subsection 5.3.1) and the data collection instruments: questionnaires (subsection 5.3.2) and interviews (subsection 5.3.3).

5.3.1 Participants

The choice for the main group of participants was associated with my research interest in pre-service teacher education, which motivated the investigation of the idea of *critical sense* in interpretation of media graphs among student teachers who would be responsible for graphing teaching in primary schools.

Initially, it was decided that the main group of participants would be comprised of British primary school student teachers who were taking the 2nd year of an undergraduate education course: a similar group to the pilot study participants. However, during conversations with the undergraduate students' tutors and my supervisor, there was a possibility of also collecting data from students taking PGCE (Postgraduate Certificate in Education). The PGCE is a one year course which gives *Qualified Teacher Status* (QTS) to graduates to develop their teaching career. These PGCE students were more varied in ages and background.

The data collection from undergraduate and PGCE students would allow a comparison of the processes of interpretation of media graphs between those two different groups. For example, it was expected that the level of academic and professional background associated with student age could be a differential element of the performance of students because older students generally have a wider range of life experiences which could influence their answers from those younger. However

my previous study indicated that academic background is not a determinant aspect of quality of interpretation of media graphs (Monteiro, 2002).

During the Spring Term in 2003 an opportunity occurred to go to Brazil and collect data among Brazilian teacher students utilising a translated version of the same questionnaire used in Britain. I anticipated that the socio-cultural differences between the British and Brazilian participants would be another interesting parameter of discussion. Therefore, in April of 2003 this data collection was carried out in the Northeast of Brazil among student teachers who were also taking 4-year undergraduate course in education (*Curso de Pedagogia*).

Unlike the British undergraduate participants the Brazilian student teachers do not follow school subject specialisms (Amato, 2004; Marcondes, 1999). In addition to the status of primary school teacher, the students can also take two different specialisms: *educational supervision* and *school management*. Therefore, they take different routes which allow them to be specialists in those two areas. For example, in order to be a school manager specialist they need to take the *Statistics applied to Education* course.

Most of the Brazilian participants are from working or lower middle social classes in full time jobs. A substantial number of these participants work as well as study. However, not all of them work in the educational field.

The university where the Brazilian participants were taking the course demands higher scores from an exam which they took at the end of the secondary school than other universities. Therefore, the Brazilian participants' performance in secondary school is generally better than the regional average which puts them in a similar position to the British participants who were studying in a university with good reputation and high entry requirements.

I anticipated that the use of the same questionnaire tasks could allow a comparative analysis between the responses from the British and Brazilian. However, it was not intended to develop a comparison of the levels of performance among Brazilian and British participants. Instead I planned to identify general similarities and

differences in order to understand the phenomenon of *critical sense* in interpretation of media graphs.

In conventional use of quantitative methods the purpose of sampling is to use a relatively small number of respondents to find out about a larger specific group termed population (Gorard, 2003). However, in this study the groups of participants which completed the questionnaire were not chosen to be statistically representative of the population of student teachers in Britain or Brazil.

The ethical issues related to informed consent and confidentiality of the data collected which were discussed in subsection 4.2.1 of chapter 4 were also considered for the main study.

The next subsections present a characterization of the British and Brazilian participants based on their questionnaire responses.

5.3.1.1 British participants

The questionnaire was given to 64 second-year undergraduate student teachers who were associated with 3 class groups, and 54 post-graduate education (PGCE) students from 2 different groups. Table 5.1 (below) presents the number of participants per group by gender. In this Table, UG means undergraduate groups; PGCEM (morning PGCE group) and PGCEA (afternoon PGCE group).

Table 5.1: The frequencies of British participants per group and per gender

	Undergraduate student teachers				PGCE student teachers			
Gender	UG1	UG2	UG3	Subtotals	PGCEM	PGCEA	Subtotals	*TOTAL*
Female	24 (92%)	14 (82%)	21 (100%)	59 (92%)	22 (82%)	22 (82%)	44 (82%)	*103 (87%)*
Male	02 (8%)	03 (18%)	---	05 (8%)	05 (18%)	05 (18%)	10 (18%)	*15 (13%)*
TOTAL	26 (100%)	17 (100%)	21 (100%)	64 (100%)	27 (100%)	27 (100%)	54 (100%)	*118 (100%)*

As can be observed in Table 5.1, the vast majority of the British students were female (87%). However, only the UG3 group was completely composed of female students.

In Table 5.2 (below) the distribution of the students by age group is given.

Table 5.2: The frequencies of the British participants' ages per group

Ages	UG1	UG2	UG3	Subtotals	PGCEM	PGCEA	Subtotals	*TOTAL*
19-20	20 (77%)	15 (88%)	15 (71%)	**50 (78%)**	---	---	---	***50 (42%)***
21-25	01 (4%)	02 (12%)	01 (5%)	**04 (6%)**	17 (63%)	16 (59%)	**33 (61%)**	***37 (32%)***
26-30	01 (4%)	---	01 (5%)	**02 (3%)**	05 (18%)	05 (18%)	**10 (19%)**	***12 (10%)***
31 or +	04 (15%)	---	04 (19%)	**08 (13%)**	05 (18%)	06 (22%)	**11 (20%)**	***19 (16%)***
TOTAL	**26** (100%)	**17** (100%)	**21** (100%)	**64** (100%)	**27** (100%)	**27** (100%)	**54** (100%)	***118 (100%)***

Table 5.2 shows that the undergraduate groups were comprised of younger people than the PGCE groups. In particular, 78% of the undergraduate students were aged 19 and 20 years old while 61% of PGCE students were aged between 21 and 25 years old.

The undergraduate students' groups were following specialisms in Mathematics, Science and English. Table 5.3 (below) presents the number of participants for each class group.

Table 5.3: The frequencies of British undergraduate students per specialism

Specialism	UG1	UG2[1]	UG3	*TOTALS*
English	16 (62%)	02 (12%)	20 (95%)	***38 (59%)***
Science	10 (38%)	06 (35%)	01 (5%)	***17 (27%)***
Mathematics	—	09 (53%)	—	***09 (14%)***
TOTALS	**26** (100%)	**17** (100%)	**21** (100%)	***64 (100%)***

The 54 PGCE students had range of academic backgrounds related to 25 different courses which were completed in at least 32 different universities in England and Wales[2]. Table 5.4 below presents the number of PGCE students per degree area.

Table 5.4: The frequencies of PGCE students' area of the degrees

Degree area	PGCEM	PGCEA	*TOTAL*
Arts – Humanities	14 (52%)	08 (30%)	***22 (41%)***
Social Sciences	10 (37%)	09 (33%)	***19 (35%)***
Biological and Health Sciences	03 (11%)	08 (30%)	***11 (20%)***
Sciences (Mathematics and Physics)	—	02 (7%)	***02 (4%)***
TOTAL	**27** (100%)	**27** (100%)	***54 (100%)***

[1] All undergraduates in group UG2 had 'A' Level Mathematics at the end of secondary school.
[2] Two students from PGCEA and one student from PGGEM did not give this information.

In the group PGCEM the majority of students had degrees in Arts-Humanities and no one had a degree in Sciences. In the PGCEA there were similar percentages of students who had degrees in Arts-Humanities, Social Studies and Biological-Health Sciences (about 30% of students for each degree).

The PGCE students were also asked about any statistics course which they had attended during their first degree courses. Table 5.5 (below) presents the frequencies related to this questionnaire item.

Table 5.5: PGCE students who took any statistics course during first degree

	PGCEM	PGCEA	*TOTAL*
No	21 (78%)	16 (59%)	*37 (69%)*
Yes	06 (22%)	11 (41%)	*17 (31%)*
TOTAL	27 (100%)	27 (100%)	*54 (100%)*

It can be observed that only 31% of PGCE students had taken statistics during their undergraduate course. In PGCEA there were a higher number of students who studied statistics than in PGCEM. This could be explained by the lower number of PGCEA participants who took Arts-Humanities degree.

Despite their different specialisms and degrees all participants were taking part in a curriculum methods course in primary school mathematics that included a section on data handling. Appendix 5.1 contains a summary of the courses taken by the undergraduate and PGCE students.

5.3.1.2 Brazilian participants

The Brazilian student teachers who completed the questionnaires were also taking a curriculum methods course in primary school mathematics (see Appendix 5.1). Originally 141 questionnaires were collected among the Brazilian groups. However, 41 (29%) questionnaires were incomplete (e.g. the participant did not answer items related to the road accident graph task). The main reason for this was that some students arrived late during the questionnaire session. I decided to include only those questionnaires from students who did not arrive late. Therefore, the Brazilian sample

was composed of 100 participants who belonged to 5 different groups. Table 5.6 (below) presents the frequencies of participants per group and per gender.

Table 5.6: The frequencies of Brazilian participants per gender[3]

Gender per group	BM1	BM2	BA	BN1	BN2	*TOTAL*
Female	22 (100%)	26 (96%)	06 (86%)	19 (83%)	18 (86%)	*91 (91%)*
Male	---	01 (4%)	01 (14%)	04 (17%)	03 (14%)	*09 (9%)*
TOTAL	**22** (100%)	**27** (100%)	**07** (100%)	**23** (100%)	**21** (100%)	*100 (100%)*

It can be observed that similarly to the British participants the vast majority of the Brazilian students were female (91%). Only BM1 group was completely composed of female students.

Table 5.7 (below) shows the distribution of the students per age group is given.

Table 5.7: Frequencies of the Brazilian participants' age per group

Age	BM1	BM2	BA	BN1	BN2	TOTAL
19-20	04 (18%)	02 (7%)	---	04 (17%)	---	*10 (10%)*
21-25	13 (59%)	18 (67%)	03 (43%)	06 (26%)	13 (62%)	*53 (53%)*
26-30	02 (9%)	04 (15%)	03 (43%)	08 (35%)	04 (19%)	*21 (21%)*
31 or +	03 (14%)	03 (11%)	01 (14%)	05 (22%)	04 (19%)	*16 (16%)*
TOTAL	**22** (100%)	**27** (100%)	**07** (100%)	**23** (100%)	**21** (100%)	*100 (100%)*

It can be observed that the majority of Brazilian participants' groups (53%) were comprised of students aged 21 and 25 years old. Generally they were older than British undergraduate participants. For example, only 10% of the Brazilian participants were aged 19-20 years old while 78% of the British undergraduate participants were aged 19-20 years old.

Another characterization of the Brazilian students refers to statistics courses which some of them took previously. Table 5.8 (below) presents the frequencies related to this questionnaire item.

[3] The label for each group is related to the period of the day in which the mathematics methodology course runs: M (morning); A (afternoon); and N (night).

Table 5.8: The frequencies of Brazilian participants who took any statistics course previously

	BM1	BM2	BA	BN1	BN2	TOTAL
No	13 (59%)	22 (81%)	04 (57%)	12 (52%)	16 (76%)	67 (67%)
Yes – high school	05 (23%)	03 (11%)	02 (29%)	10 (43%)	03 (14%)	23 (23%)
Yes – university course	04 (18%)	02 (7%)	01 (14%)	01 (4%)	02 (10%)	10 (10%)
TOTAL	22 (100%)	27 (100%)	07 (100%)	23 (100%)	21 (100%)	100 (%)

Table 5.8 shows that 33% of the Brazilian participants had attended statistics during vocational courses at middle school (23%) or took a university statistics course (10%).

5.3.2 Questionnaire

The questionnaire was given to the five groups of British student teachers just before they took a data handling section in a curriculum methods course in primary school mathematics during the Autumn term (October- November) in the 2002/2003 academic year. A translated version of the same questionnaire was given to the five groups of Brazilian participants taking similar curriculum methods courses during 2003 first semester (April).

Gorard (2003) argues that the use of questionnaires is better at gathering relatively simple facts such as those collected during the pilot study questionnaire (e.g. favourite type of reading). However, for the main study I used the questionnaires to collect responses related to the participants' interpretations. Even though I considered the limitations of this instrument for the type of data to be collected I found it appropriate to have a wider number of responses from the groups of participants.

The situation in which the questionnaire was proposed to the participants was also different from the pilot study. In the main study the questionnaire was collectively given to each class group. Even though the questionnaires were self-administered (Gorard, 2003) I was present at all data collection sessions to give the questionnaire sheets, to answer eventual questions about the procedures and to make sure that the participants were not influenced by their neighbours' answers.

Table 5.9 (below) presents a summary of the research sessions in which questionnaires were given to all groups of participants both in Britain and in Brazil.

Table 5.9: Summary of questionnaire session

Activity	Description
1. Introducing the questionnaire	The tutor and/or I introduced the questionnaire, explaining aspects related to the research purposes of the session, informed consent and confidentiality. The participants were invited to offer personal contact details, if they wanted to take part in further stage of this study.
2. Completing the questionnaires	Each participant completed the questionnaires individually. Tutor and I were made sure the questionnaires were completed without the participation of another colleague.
3. Collecting the questionnaires	Each questionnaire was collected as soon as it was completed.
4. Discussing the questionnaires	A work group was proposed in which the students shared their impressions and answers with colleagues. In each group there was a reporter who summarised the discussion in a sheet.
5. Plenary	The discussions of each group were presented to the other groups by each group relater. Relationships were made between the comments about the media graphs tasks and the whole process of work groups.

The questionnaire comprised two parts. The first section contained questions which asked about individual details (see results in the previous subsections 5.3.1.1 and 5.3.1.2) and the participants' reading background experiences (which are described in further subsections). Copies of the questionnaire sheets which the participants completed are given in Appendix 5.2.

In the second part of the questionnaire there were tasks based on two media graphs. The same graphs were used as in the pilot study interviews. The rationale for the use of the same graphs was related to three reasons. Firstly, using the same graphs could provide an important comparison between the data from the pilot and main study.

Secondly, the process of choice of graphs and the analysis of responses produced for the pilot study indicated that the topics associated with those graphs were familiar to both British and Brazilian participants. It was considered that contraception and fertility as well as road accidents are important and controversial themes in current Brazilian society. For example, in recent period from the data collection a long, large scale campaign was carried out by the local government about

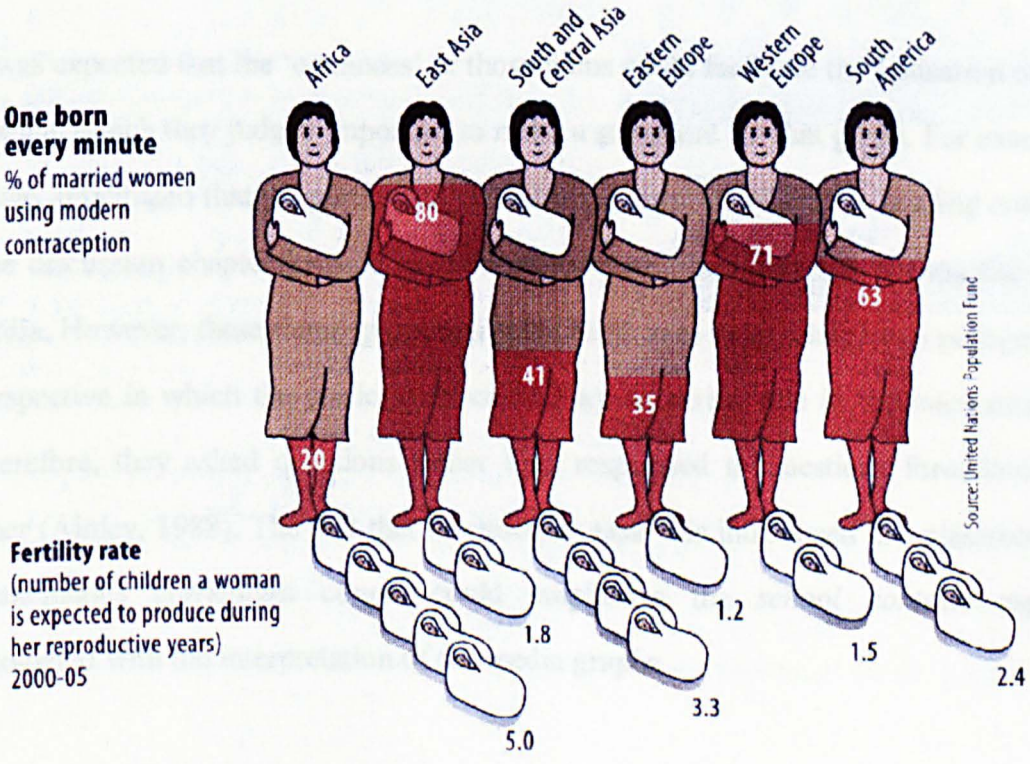
traffic education which involved most of the population (motorists and pedestrians). This accessibility to theme could avoid interpretation difficulties related to the lack of knowledge about a determined theme.

Thirdly, I considered that the use of the same media graphs could provide a development of the methodological procedures which could be connected with the data analysis and discussion developed for both pilot and main study.

Although the same graphs were used in the main study, it should be emphasised that the pilot study tasks with the media graphs were methodologically different. For example, the data collection instrument utilised in the main study was questionnaire which asked for written answers from the participants.

The process of selection of the graphs which comprised the research tasks were discussed in the section 4.2.5 of chapter 4. In the following subsection 5.3.2.1 the questionnaire items related to contraception-fertility graph are considered. The further subsection 5.3.2.2 describes aspects of the road accidents task.

Figure 5.1: Graph reprinted from The World in 2002, The Economist, 2001, p.132



5.3.2.1 Contraception-fertility graph and related questionnaire items

The first task was composed of a media graph which presented data related to the percentage of contraception and fertility rate in some world areas. Figure 5.1 (above) shows a copy of the graph used.

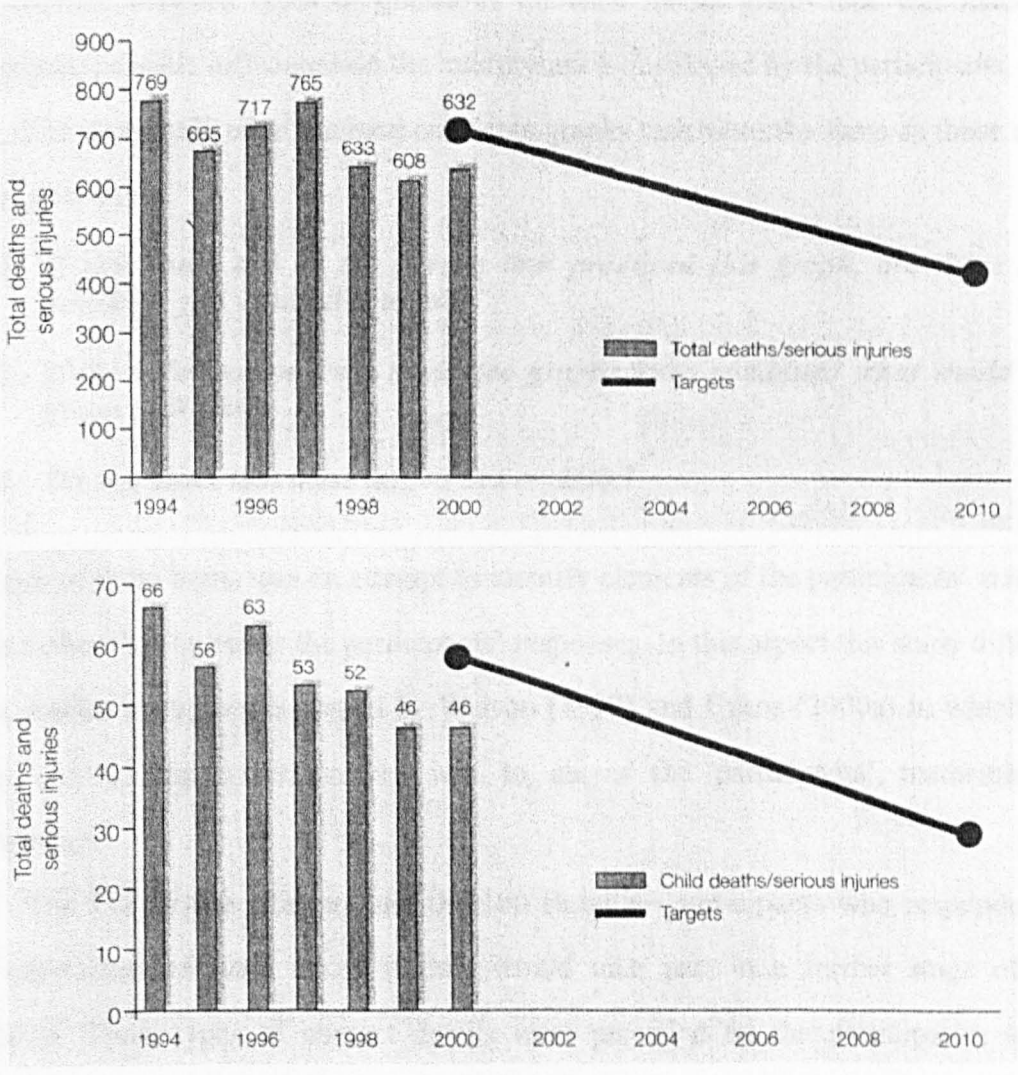
As discussed in chapter 4, in the pilot study the participants' comments were more limited during the interpretation of the contraception-fertility graph than in the road accidents graph task. For the main study task I considered that additional items could provide better opportunity to the participants to engage with the data displayed on contraception-fertility graph.

Therefore, the items introduced asked the participant to produce positive and negative statements about the graphs:

1. ***Write one or two sentences about a positive message, which could be given by this graph.***
2. ***Write one or two sentences about a negative message, which could be given by this graph.***
3. ***If you could talk to the person that produced this graph, are there any questions you would like to ask?***

It was expected that the 'openness' of those items could facilitate the utilisation of any element which they judged important to make a statement for that graph. For example, it was anticipated that the participants could utilise aspects related to *reading contexts* (see discussion chapter 2) such as those developed when they are reading the print media. However, these items (particularly the third one) were related to a pedagogical perspective in which the participants could play an active role in the interpretation. Therefore, they asked questions rather than responded to questions formulated by other (Ainley, 1988). The fact that the research task was introduced in a classroom of mathematics curriculum course could emphasise the *school contexts* aspects associated with the interpretation of the media graphs.

Figure 5.2: graphs reprinted from *Quality of life in Warwickshire*, 2001, pp. 93-94.



5.3.2.2 Road accidents' graph and related questionnaires items

The second media graph task comprised two graphs (see Figure 5.2 above) reprinted from an annual report called *Quality of life in Warwickshire* (Warwickshire County Council, 2001), that includes economic, social, and environmental indicators. As discussed in section 4.2.5.2 of chapter 4, these graphs also had particularities related to displaying of data.

Unlike the items asked about contraception-fertility graph some of the items related to the road accidents graph were about specific aspects displayed on the graph. For example, it was asked about how realistic the targets presented on the graph were.

The contrast between types of questions for each media graph task was made to investigate possible influences on the interpretation developed by the participants.

The items utilised in the road accidents graphs task were the same as those used in the pilot study.

1. ***If you could talk to the person that produced this graph, are there any questions you would like to ask?***
2. ***If the information from these two graphs were combined what would the graph look like?***
3. ***Do you think that these targets are realistic?***

The use of these items was an attempt to identify elements of the participants' *critical sense* rather than to assess the participants' responses. In this aspect this study differed from studies using media graphs by Watson (1997) and Evans (2000a) in which the main aim of the questionnaires was to assess the participants' mathematical knowledge.

The 118 British students and the 100 Brazilian participants who responded to the questionnaires were asked if they would take part in a further stage of the research. Three types of contact details were provided by the participants: email address, telephone number or home address. The vast majority of these students gave an email address. For that reason and for practical issues (e.g. easier and quicker way to contact the participants) I decided to contact only the students who provided email address.

I also considered conducting interviews with the Brazilian participants. However, it became unviable for a number of practical reasons. A further attempt was made to collect data from the Brazilian students by online questionnaires. Nevertheless, this methodological procedure was unsuccessful because only a few students could respond, and on the basis of consideration of issues associated with the reliability and validity of this type of data collection, I made the decision not to pursue this further.

Table 5.10 shows the number of students who responded to the questionnaire, contacted to give interviews and those interviewed.

Table 5.10: Details about the number of participants in different stages of the research

Participants	Respondents	Contacted	Interviewed
British Undergraduates	64	18	07
British PGCE	54	18	06
Brazilian Undergraduates	100	54	---
TOTAL	218	100	13

It can be observed in table 5.10 that I contacted the 36 British respondents of questionnaire. I had a positive reply from 20 participants but only 13 were interviewed (11% of the British total). The next subsection describes aspects of the interviews.

5.3.3 Interviews

In this study the use of interviews was not a form of mutual confirmation or a validation of the data collected from the questionnaire. Instead, it was my intention to have two complementary datasets (Gorard and Taylor, 2004).

The use of interviews for new data collection was aimed at obtaining more detailed elements from the participant's interpretations. According to Kvale (1996) qualitative interviews are an important methodological instrument which can provide the opportunity to investigate the nuances and meanings of the participants' interpretations.

During the period between the data collection from the questionnaires and the interviews, a preliminary analysis of the participants' responses for the questionnaires was developed as well as the continuation of the literature review process. These were important procedures which helped to identify aspects which could be investigated in the further data collection. Therefore, in the light of the partial literature review and the preliminary manual categorization of the participants' responses, I decided to explore the three level questioning discussed by several authors who had investigated

the interpretation of graphs: *reading the data*; *reading between the data*; and *reading beyond the data* questions (as discussed in subsection 2.7.2).

Table 5.11 (below) presents a summary of the interview plan which includes the questions and the aims related to each stage of the interview.

Table 5.11: Interview plan according to questions asked

Parts of the interview/Aims	Contents/Questions
Briefing – establishment of rapport for the interview. Obtain informed consent from the interviewee. Introduce the student to the interview tasks	Generic comments related to the data collection and ethical issues (privacy and confidentiality) Do you remember the questionnaire that you completed last November? What do you remember about it?
Reading the data questions (Contraception-fertility graph)	What is the percentage of married women using modern contraception in South America? What is the fertility rate in South America?
Reading between the data questions (Contraception-fertility graph)	Which region has the lowest fertility rate using modern contraception? Which regions have a higher percentage of married women using modern contraception than South America?
Reading beyond the data questions (Contraception-fertility graph)	What is your prediction for the fertility rates of South America between 2006 and 2010? If the percentage of married women using modern contraception in Argentina is 70%, what would you expect fertility rate to be?
Recall of questionnaire responses (Contraception-fertility graph items)	Do you remember the questionnaires items? Do you remember your answers at that time? Specific questions to clarify the interpretative process related to those answers.
Reading the data questions (Road accident graphs)	What is the total of number of deaths and serious injury per year? What is the lowest actual death and serious injury rate?
Reading between the data questions (Road accident graphs)	Between 1994-1995, and 1997-1998, there was a decline in the number of deaths and serious injuries. Which period represents the greatest decline? Which years represent the highest and lowest number of deaths and serious injuries?
Reading beyond the data questions (Road accident graphs)	What is your prediction for death rate and serious injury in 2001? If the targets for 2000-2010 were met, what do you think the pattern might be for 2010-2020?
Recall of questionnaire responses (Road accident graphs items)	Specific questions to clarify the interpretative process related to those answers.
Debriefing – Finishing the interview tasks. Make connections with the pedagogical aspects of interpretation of the graphs	Asking opinion about those research tasks and the graphing teaching in primary school.

In this study these three types of questions were used in a distinct way from previous studies (e.g. Curcio, 1987; McKnight, 1990). For example, Curcio proposed conventional school graphs in multiple choice tasks which restricted the range of responses which could be given. Thus students could not have the opportunity to display aspects of their knowledge and experiences which might play an important role in their reading of the graph. The formulation of these types of questions in the context of an interview provided an opportunity for the participants to think about their own interpretation of the graphs.

The choice for this typology of questions was also based on outcomes from the data analysis of questionnaire responses. For example, I considered the need to investigate the use of items which were previously used as methodological approaches to focus the students' attention on specific aspects of the data displayed on graphs.

At the beginning of the interviews, each participant was asked whether they remembered the questionnaires which they had completed. All of them answered that they vaguely remembered that the survey items were related to graphs. However, they immediately recognised the graphs (Figures 5.1 and 5.2) when they were presented to them during the interview.

Although the interviews were semi-structured with a schedule which included questions previously listed (above), there were some incidents during the interview which generated other specific questions (details about the interviews are discussed in chapter 7).

The interviews also comprised a *stimulated recall* (Calderhead, 1981) of the participants' questionnaire responses. Calderhead states that *stimulated recall* is a research method which can provide a means of collecting data concerning teachers' thoughts and decision-making. In this study, *stimulated recall* was used to collect the interviewees' retrospective reports of their interpretative process when they were responding to the questionnaires' items. The interviewees were invited to reread and reanalyse their responses and make a retrospective report of their thoughts when they were answering the questionnaire items. I also asked additional questions related to

specific elements of their interpretation which needed to be clarified. Although the majority of participants made comprehensive comments about their questionnaire responses some of them did not want to comment or made very few observations about their interpretative process.

This *recall* was also a way to validate my analysis of the questionnaire data. Strauss and Corbin (1998) suggest that the presentation of raw data to respondents can generate reactions which help to identify and compare convergent and divergent aspects of researcher's data analysis.

The interviews were conducted in a quiet and well illuminated room at a university building which was reserved for that purpose. Each student was interviewed individually. The material was displayed on a desk and the student was seated in a position which allowed her/him to participate in the interview comfortably.

The copies of the graphs were presented in plastic folders. Each question was asked orally as well being shown printed on a sheet. This procedure allowed the participant to reread the question if they wanted to do this.

The timing of the interviews varied according to the availability of the participants. Generally, the interviews happened between 10 a.m. and 2 p.m. The Interviews lasted between 30-60 minutes. With the permission of the participants each interview was audio recorded and videotaped. The video camera was placed on a tripod which was situated beside the desk. The mini-disk recorder and a microphone were placed on the table. Despite the visibility of the recording apparatus the participants did not seem intimidated by the equipment.

The audio and video recording provided more accurate data for analyses, such as aspects of body language and intonation of participants' speech. The use of digital devices also facilitated the transcription of the interviews and analyses of the videotaped situations because audio and video files could be easily manipulated.

5.4 Data Analysis

The process of data analysis of the main study was integrated with the data collection and construction of provisional conceptual frameworks related to *critical sense* in interpretation of media graphs. For example, the preliminary analysis of questionnaires suggested an expansion of the literature review was needed which also affected the construction of the interviews.

The data from the questionnaires and the interviews generated two complementary datasets which enabled me to explore elements and processes related to the phenomenon of *critical sense* in interpretation of media graphs. This section presents an overview of the data analysis process which is further discussed in the following chapters.

5.4.1 Coding the questionnaires

I started to categorise manually the participants' responses from the questionnaires. However, the process seemed very hard because multiple possibilities of classification could be made for the same 'sentence' or 'question' formulated by one student.

Reflection about the difficulties experienced during the manual categorisation of the questionnaire responses led me to use software as methodological tool. Among the possible alternatives I chose NVivo which is software package which assists the organisation and analyse of qualitative data designed by QSR. NVivo allows one to import and code textual data; edit the text without affecting the coding; retrieve, review and recode coded data; and search for combinations of words in the text or patterns in the coding. This software package seemed to have the capacity for supporting an iterative approach to analysis. This decision was initially made on the basis of possible options discussed on research methods courses when I explored different packages.

The initial 'self-training' demanded time and reading of manuals which explain the basic procedures. Much time also was consumed transforming my Microsoft word

documents in readable documents for the NVivo. However, NVivo improved my strategies to code my data that came from questionnaire responses. In addition, NVivo allowed me to view my codes and to analyse the data more easily than manual analysis.

The initial stage of analysis was the open coding[4] which was comprised of a list of codes related to different aspects of the responses. This open coding process fractures data as a way of managing and understanding unstructured data (di Gregorio, 2003, p.82). However, there is a risk to open coding: generating too many codes without reflection. Therefore, it was an important decision to move on to a second stage of coding which was the rearrangement of open codes. In this phase I refined, discarded and grouped the initial codes in the NVivo Tree Node Area.

Working with NVivo allowed me to develop notes which kept chronological decisions that I made when I was organising my data and the insights that I had when I was coding the data. This procedure helped me to develop my thinking about the categorisation of the data and its relation with the theoretical aspects (di Gregorio, 2003). NVivo was an important tool for the data analysis of this study because it facilitated the interpretation of the data through the possibilities of organisation of the data.

Welsh (2002) states that much has been written about the use of computers in qualitative data analysis with some commentators expressing concern that the software may "guide" researchers in a particular direction. On the other hand, Welsh also emphasises that other authors agree that software package like NVivo serve to facilitate an accurate and transparent data analysis process whilst also providing a quick and simple way of counting who said what and when, providing a reliable, general picture of the data.

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[4] The terms code and coding have been introduced in qualitative research followed specific methodological and epistemological issues. Although I am aware of the particular uses of these terms in this study I use codes and coding as being synonymous with categories and categorisation or classification.

5.4.2 Analyses of the interviews

After transcription of all interviews I also considered the use of NVivo for the data analysis of the interviews. However, as observed by di Gregorio (2003) this software seemed to duplicate manual analysis of the longer written texts. Therefore, the analysis of interviews was not software based.

In order to analyse the interviews I used a microanalysis approach based on suggestions from Strauss and Corbin (1998). This approach began with a scanning of the whole transcription of each interview. I produced three types of observations from this scanning of the participants' interviews. The first type of observation is related to inclusion of words or sentences which complement aspects of the participants' speech. The second type of observations refers to comments based on my analysis of the participants' interpretation. A third type of observation was associated with short discussions which related the extract to theoretical aspects from the framework or to studies of the literature review. Examples of these observations are given in the extracts of interviews in chapter 7.

After this process of scanning and commenting on the interviews as whole, I selected sections from several interviews which seemed particularly interesting to discuss the elements and processes related to *critical sense* in interpretation of media graphs. I developed a line-by-line analysis of these sections with the rationale of identifying in more detail the constitution of the elements and processes related to the phenomenon investigated.

An important aspect of the data analysis of the interviews is related to validation. Strauss and Corbin (1998) emphasise that in qualitative research subjectivity is an issue. These authors suggest that researchers should take appropriate measures to minimise its intrusion into their analyses. However, in qualitative research, objectivity does not mean controlling the variables. Based on suggestions from Strauss and Corbin, I used two techniques to validate my analyses of the interviews:

- **Periodical evaluation of data analysis process**: The continual evaluation of categories, questions, hypotheses and explanations consist of a strategy to validate the study. Therefore I was constantly discussing with interlocutors aspects of this research. Firstly, I was always re-examining the process with my supervisor Janet Ainley with who I closely worked. Secondly, I periodically shared ideas and suggestions with other PhD student colleagues. Thirdly, I received feedback of reviewers and audiences from several conferences in mathematics education where I presented partial discussions of my findings.
- **Comparison of incidents**: Another strategy refers to internal comparisons between several incidents from different pieces of data collected. For example, in my analysis I compared similar incidents from different interviews in order to identify and conceptualise specific elements of *critical sense* in the participants' interpretations.

5.5 Summary of chapter 5

- In order to investigate the *critical sense* in interpretation of media graphs. I developed a combined method which *interplayed* between qualitative and quantitative data that was collected by use of questionnaires and interviews.

- The questionnaire comprised two parts: individual details items and media graphs tasks. The same media graphs used in the questionnaires composed the interview tasks which comprised three types of questions: *reading the data*; *reading between the data*; and *reading beyond the data.*

- 13 British participants volunteered to give interviews which comprised the second dataset of the main study.

- The data analysis of the questionnaires was *NVivo* based, and a microanalysis approach was developed with the data from the interviews.

Chapter 6

Findings from the questionnaires

6.1 Overview

As was discussed in previous chapters, the vast majority of the studies which have investigated graphing have focused on students' performance and suggested prescriptive approaches to improve the teaching without much consideration of teachers' knowledge of this topic. The few studies in mathematics education which have examined teachers' knowledge in graphing focused on the teachers' pedagogical skills to carry out tasks or to assess students' performance in graphing (e.g. diSessa et al., 1991; Hadjidemetriou and Williams, 2002b). In this study my interest in collecting data among primary school student teachers is related to my aim of exploring the process of interpretation of media graphs with those who are (or will be) involved in teaching graphing.

This chapter discusses the findings from the questionnaires' responses which explored elements of *critical sense* in student teachers' interpretations of media graphs. From the analyses of the pilot study data I could identify that several elements might be involved in interpretation of media graphs. At the stage of collecting questionnaire data I was conceptualising *critical sense* as a skill or ability to *mobilise* and *balance* several elements related to the interpretation.

I recognise that a questionnaire is an instrument of data collection which can limit the possibilities of interpretation of media graphs (Watson and Callingham, 2003). For example, the questionnaire examines only the written aspects of interpretations (Janvier, 1981), and does not allow a more interactive process which could identify explicit aspects of the interpretations of graphs (Watson and Chick, 2004). Therefore, I recognised that the exploration of *critical sense* in interpretation of media graphs utilising a questionnaire could gather data which does not provide evidence of all elements which comprise this phenomenon. For example, it was

expected that written answers from participants would not exhibit affective aspects associated with *critical sense* in graphing (Evans, 2000a). However this methodological tool was utilised because it could collect a large amount of data which could offer evidence of *critical sense* elements among different groups of student teachers in Britain and in Brazil.

As discussed in chapter 5, the data from questionnaires and from interviews are mutually complementary. Although I expected that the use of interviews would get more complete data about the elements and processes involved in *critical sense* in interpretation of media graphs, the questionnaires also indicate important aspects from different groups of participants.

The first part of the questionnaire was composed of items which asked about the participants' individual details as well as their academic and reading background (see Appendix 5.2). The individual details collected provided a characterisation of the participants which constituted an additional element for the analysis. The second part of the questionnaire served to explore *critical sense* involved in participants' answers to items related to media graphs.

This chapter contains the description and analysis of the participants' responses. The main methodological aspects associated with elaboration, and utilisation of the questionnaire was discussed in chapter 5. Therefore, section 6.2 introduces elements of the questionnaire data analysis. Section 6.3 presents the data related to reading background items; section 6.4 focuses on the responses related to the contraception-fertility graph task; and section 6.5 presents the results from the road accidents graphs task. Section 6.6 presents a general discussion the questionnaire findings. Finally, section 6.7 summarises chapter 6.

6.2 Analysis of questionnaire data

The procedures of ordering and cataloguing the questionnaires were developed immediately after the data collection in order to facilitate the data analysis. Each completed questionnaire was placed in a plastic A4 sleeve and arranged in folders

according to the group of participants to which it belonged. Each questionnaire was labelled with a code which helps the analysis process.

A preliminary manual data analysis of the British questionnaires started during the Autumn term in 2002. This initial manual categorisation was important to identify general aspects from the answers produced. For example, the responses seemed to be similar to the pilot study findings despite the fact that there were a larger number of responses. A preliminary range of main categories was produced from the manual coding, such as: questions and sentences about the production of the data; and questions about the social aspects involved in the data displayed on the graph.

The initial manual categorisation was followed by a software based coding. During this data analysis stage the speed and variety of the categorisation was improved. Therefore the NVivo coding stage started with a production of many codes which tried to address many possible aspects of the data collected. Gradually the codes were replaced, reformulated and grouped according to analytical relationships which were established.

The questionnaires' initial items about the individual details and academic background were described in subsection 5.3.1 of chapter 5. Those items referred to participants' gender, age and their specialism or degree. The vast majority of the groups were composed of females (around 90% of each group). Generally the British undergraduate students comprised younger participants (78% of 19-20 year-old). The majority of British PGCE students (61%) and Brazilian participants (53%) were aged 21-25.

In an early stage of analysis tables were produced which described in detail the frequencies of responses for each group of participants (similar to the tables presented in chapter 5). Although this initial analysis revealed that there were differences of responses to some parts of the questionnaires these differences were not consistent. Therefore, I considered that in this chapter the frequencies of responses could be presented in subtotals which refer to British undergraduates, British PGCE students, and Brazilian undergraduates.

The following section discusses questionnaire items which collected data about the participants reading background.

6.3 Responses to reading background items

It was expected that a large number of participants had access to print media. However, it was necessary to gain evidence of the reading situations in which they may have access to media graphs. Therefore, an attempt was made to formulate items which collected information that characterised the frequency, the preference, the sources, and the type of access which those students could have in their reading situations.

The first aspect coded was related to responses to the item which asked about the participants' most frequent *type of reading*. Table 6.1 (below) presents the occurrence and percentage of responses for each category of reading indicated by the participants. The same participant could indicate more than one category of reading.

Table 6.1 – Frequencies of participants' types of readings per group

Types of reading	British Undergr.	PGCE Students	Brazilian Undergr.	TOTALS
Newspapers	36 (30%)	31 (28%)	87 (43%)	**154 (36%)**
General literature	58 (48%)	48 (44%)	47 (23%)	**153 (35%)**
Academic literature	15 (12%)	19 (17%)	53 (26%)	**87 (20%)**
Magazines	10 (8%)	06 (6%)	17 (8%)	**33 (8%)**
Others	01 (1%)	05 (5%)	---	**06 (1%)**
TOTAL	**120** (100%)	**109** (100%)	**204** (100%)	**433 (100%)**

In Table 6.1 the categories *Newspapers* and *Magazines* include titles published locally, nationwide and internationally. *General literature* is a category associated with a variety of book types such as fiction (e.g. novels, romance and fantasy literature) and non-fiction (biographies and self-improvement). *Academic literature* includes books and papers related to the course or professional field in which the participant is engaged.

Generally it can be observed that the most frequent types of reading are *newspapers* (36%) and *general literature* (35%). However, the specific figures related to the British groups indicated that the most frequent type of reading among those participants is *general literature*. The higher occurrence of *newspaper* as frequent reading among Brazilian participants could be related to a number of possible factors. In Brazil *general literature* is associated with holiday activities. A number of Brazilian participants work as well as study. They have limited time for leisure reading such as *general literature*. In addition, in Brazil there are commercial and educational campaigns which encourage the population to read (consume) newspapers (e.g. some teachers have deliveries of newspapers during weekends paid for by local government and some pedagogical magazines are also delivered for very low cost).

Table 6.1 also indicates that another frequent type of reading amongst the participants refers to their academic daily activities. This type of reading was also higher amongst Brazilians than British participants.

Table 6.2 (below) shows the occurrence of answers related to the preference for certain types of reading.

Table 6.2 – The frequencies of participants' favourite reading per group

Types of reading	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
General literature	72 (64%)	61 (63%)	71 (51%)	**204 (58%)**
Magazines	25 (22%)	16 (17%)	19 (14%)	**60 (17%)**
Newspapers	15 (13%)	12 (13%)	26 (19%)	**53 (15%)**
Academic literature	---	04 (4%)	18 (13%)	**22 (6%)**
Others	01 (1%)	03 (3%)	06 (3%)	**10 (3%)**
TOTAL	**113** (100%)	**96** (100%)	**140** (100%)	**349 (100%)**

The results displayed on Table 6.2 suggest that for the majority of participants (58%) the most frequent type of favourite reading is *general literature*. *Magazines* and *newspapers* respectively represent the second and the third most enjoyable type of reading. *Academic literature* is mentioned for a small percentage of students (6%).

The participants were also asked to whether or not they subscribed any periodical. This specific question was added in order to identify sources of reading which were frequently delivered for them and which most probably could be read on a regular basis.

In Britain there are two types of *subscriptions.* There is the *delivery* of newspapers or magazines which can be directly arranged with local retailers for short periods of time (e.g. weeks or months), and there are *subscriptions* for periodicals for a longer period (e.g. the subscription of *The Economist* for one year). In Brazil there is only the second type of subscription. In this study the terms *subscriber* and *subscription* are related to both types of periodical delivery. Table 6.3 (below) presents the percentages of subscribers among the participants.

Table 6.3 – The frequencies of periodical subscribers among the participants

Subscriptions	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
No - Blank	47 (73%)	38 (70%)	28 (28%)	**113 (52%)**
Yes	17 (27%)	16 (30%)	72 (72%)	**105 (48%)**
TOTAL	**64** (100%)	**54** (100%)	**100** (100%)	**218 (100%)**

Generally, it can be observed that an average of 28% of the British participants were subscribers of any periodical. Among the Brazilians the percentage of subscribers is considerable higher (72%). However, it should be noted that some British students may have interpreted *subscription* as *delivered,* and they might have negatively responded when they actually had frequent access to this type of reading.

Table 6.4 specifies the types of publications which the participants subscribed to.

Table 6.4 – The frequencies of subscribed periodicals mentioned by the participants

	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Magazines	17 (65%)	15 (43%)	105 (70%)	**137 (65%)**
Newspapers	09 (35%)	20 (57%)	46 (30%)	**75 (35%)**
TOTAL	**26** (100%)	**35** (100%)	**151** (100%)	**212 (100%)**

It can be observed that all mention of subscriptions was related to *magazines* and *newspapers*. Generally *magazines* are the most frequent type of subscription. However the PGCE participants did not follow this pattern.

Among the magazines subscribed to, academic titles were more frequent than other kinds of magazines among all groups of participants (see Table 6.5 below).

Table 6.5 – The frequencies of types of magazines subscribed to by the participants

Types of Magazines	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Academic – Educational	11 (65%)	06 (40%)	56 (53%)	**73 (53%)**
News reports	---	02 (13%)	29 (28%)	**31 (23%)**
Entertainment	06 (35%)	04 (27%)	17 (16%)	**27 (20%)**
Others	---	03 (20%)	03 (2%)	**06 (4%)**
TOTAL	**17 (100%)**	**15 (100%)**	**105 (100%)**	**137 (100%)**

Academic and educational magazines are associated with topics such as: research studies, school subjects, and pedagogical issues. The high occurrence of this type of magazine might be explained by easier and cheaper access to some magazines for teachers (e.g. *Times Educational Supplement* - *TES* for British participants and *Nova Escola* for Brazilians).

Generally the second most frequent type was *news report* (e.g. *Newsweek* – Britain; *Veja* – Brazil). However, this type was not mentioned among British undergraduates.

Entertainment magazines approach one or a number of topics such as: fashion, food, health, leisure, sports, music, sex, women's life. In general terms this was the third most frequent type among the participants. It can be observed that *entertainment magazines* were actually the second most frequent type among the British participants.

Even though it could be expected that graphs are more likely to be found in *news reports* or *educational magazines*, graphs may be found in 'entertainment' ones. For example, from an investigation of the contents related to the magazines mentioned by the participants I identified the use of 18 graphs in an 11 page-section which

presented a nationwide survey in the article: "people speak: what you really think about the future of the monarchy" (2003) in an issue of the magazine *Hello*. Therefore, the higher frequencies of *entertainment magazines* among British participants does not necessarily mean less opportunity of access to graphs in reading situations of print media.

It was also identified that the majority of participants (52%) had access to other publications which are not delivered to them (see Table 6.6 below).

Table 6.6 – The frequencies of non-subscribed periodicals' titles mentioned by the participants

Types of reading	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Magazines	69 (49%)	38 (41%)	142 (58%)	**249 (52%)**
Newspapers	74 (51%)	55 (59%)	99 (41%)	**228 (47%)**
Academic	---	---	03 (1%)	**03 (1%)**
TOTAL	**143** (100%)	**93** (100%)	**244** (100%)	**480 (100%)**

The most frequent type of non-subscribed reading among the British participants was *newspaper*, and among the Brazilians it was *magazine*.

Table 6.7 (below) shows the incidence of types of magazines to which the participants had access.

Table 6.7 – The frequencies of non-subscribed types of magazines mentioned by the participants

Types of Magazines	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Entertainment	57 (83%)	26 (68%)	28 (20%)	**111 (45%)**
News reports	01 (1%)	03 (8%)	80 (56%)	**84 (33%)**
Educational	11 (16%)	09 (24%)	30 (21%)	**50 (20%)**
Religious	---	---	04 (2%)	**04 (2%)**
TOTAL	**69** (100%)	**38** (100%)	**142** (100%)	**249 (100%)**

It can be observed that the vast majority of British participants mentioned *entertainment* while the majority of Brazilian students mentioned *news reports* as the most frequent type of non-subscribed periodicals.

The questionnaire also contained a table with pre-coded items which asked the participants about different types of computer use. For each type of computer use there were four answer choices related to how often they were used: daily, weekly, monthly or never. Appendix 6.1 shows a table with all frequencies of the participant's answers for those pre-coded items. The answers for these multiple-choice items gave a general view about other reading situations with which the participants would be engaged.

Table 6.8 (below) presents the most frequent activity as *searching* which is a type of computer use which is more related to media reading situations. The percentages are related to the actual number of participants because each student gave one answer for the multiple choice items related to the types of computer use.

Table 6.8 – The most frequent period of the participants' computer use per group

Activity	Frequency	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Search	Weekly	39 (61%)	29 (54%)	53 (53%)	**121 (56%)**
Number of participants		**64** (100%)	**54** (100%)	**100** (100%)	**218 (100%)**

The results for this computer based reading activity does not give specific information about the kind of reading the participant searched for on the Internet. For example, we could not have precise information whether or not the materials searched for might contain statistics graphs.

The analysis of the frequencies of the British participants' responses did not reveal much difference between the reading backgrounds of undergraduate and PGCE student teachers.

Despite the cultural differences between British and Brazilian students, no great differences between their reading backgrounds were observed. However, some particular aspects related to Brazilian and British participants' responses were identified from the analyses of the frequencies.

Firstly, a larger percentage of Brazilian participants were frequent readers of *newspapers* which generally publish graphs. On the other hand, among British

participants *general literature* was the most frequent category of reading which is not generally associated with the use of graphs. Nevertheless, the majority of participants from all groups declared that *general literature* is the favourite type of reading. These frequencies suggest that the occurrence of *frequent reading* could be associated with circumstantial aspects, such as: the academic activities of teacher education, or the market which encourages the consuming of magazines and newspapers.

Another aspect observed is that the frequencies of responses of Brazilians and British participants were differently related to the forms of access to periodicals. The majority of Brazilians (72%) subscribed to at least one periodical while among the British participants the percentage average was 28%.

The information gathered through the questionnaires suggests that a substantial number of participants were readers of *newspapers* and *magazines* (44%). However, this might be also an indication that the interpretation of media graphs is not a frequent situation for a substantial number of participants.

Another aspect which can be discussed is that the graphs which comprised the research tasks came from media publications which were not mentioned by the participants. On the one hand, this procedure enables the investigation of participants' interpretation of graphs which they had not seen before. On the other hand, those graphs which composed the research tasks represented examples of types of media graphs frequently published in other periodicals which included those mentioned by the students.

It was considered that there are a number of other occasions in which the participants could have access to print media graphs which were not covered by the questionnaire (e.g. adverts, business reports etc). I also recognise another situation in which participants might have access to media graphs are television programmes such as news reports which also frequently present graphs to illustrate aspects of the topic discussed (e.g. daily economical reports exhibit graphs). However, these reading situations involve other particularities different from graphs presented in print media

publications (e.g. the time of exhibition and the oral comments which are generally associated with TV graphs).

6.4 Responses to contraception-fertility graph items

As previously described (see chapter 5) the contraception-fertility graph task comprised three items. The first and second items invited the participants to summarise the ideas of the graph in "positive" and "negative" statements. It was expected that these initial items would facilitate interpretations related to the participants' personal view about the data. Their personal interpretation could stimulate the *mobilisation* of participants' previous knowledge, experiences and feelings related to *critical sense*. This expectation was based on the discussion of pilot study findings (see chapter 4).

The third item of the contraception-fertility task was related to an enquiry dimension of the interpretative process (Wild and Pfannkuch, 1999; Strauss and Corbin, 1998). When the participants were invited to imagine that could asked questions it was expected that they were actually questioning themselves about the data displayed on the graph.

According to Gal (2002) adult readers should maintain in their minds a list of "worry questions" regarding the statistical information being communicated or displayed, such as: *Where did the data come from? How reliable or accurate were the instruments or measures used to generate the reported data? Is a given graph drawn appropriately?* However, the aim of the third item related to the contraception-fertility graph was to present a questioning situation which was not focused on the technical dimension of the interpretation of graphs because it would restrict the exploration of the components of *critical sense*.

This section describes the frequencies of participants' responses which were the result of a categorisation process which analysed aspects of their answers. The coding of open questionnaire items is not an easy task because it needs to take account of what participants meant in a particular answer. In fact, this was an important issue

which I faced at the initial categorisation phase. In a further stage, attempts were made to conduct analysis which was based on the components of the sentences and questions produced. Focusing on descriptive aspects of the data avoided over interpretation.

An example of this approach can be given by the analysis of the following 'positive sentence' produced by 12G1 (British undergraduate student): "*Modern contraception does often work if used correctly*". The first idea which might be inferred from this sentence is that the student established a relationship between the information from both datasets presented on the graph which are related to contraception percentages and fertility rates. This inference could be based on the fact that the student emphasised the effect of the contraception (*does often work*). However, the sentence does not explicitly refer to the fertility graph. Therefore, the initial inference might give a distorted picture of the data[1]. The account could have been made on the basis of opinion only. Therefore, it was decided to develop an analysis of the participants' sentences and questions which was based on explicit features of the written responses.

The manual categorisation of the participants' responses was difficult because the participants' responses involved several distinct aspects which needed to be analysed in connection with each other. For example, a sentence produced by a participant could be comprised of reference to numerical data displayed on the graph associated with her personal opinion about the information interpreted. The use of NVivo facilitated the process because it made possible to 'visualise' this process of categorisation.

The following subsections (6.4.1 and 6.4.2) describe the participants' responses for the task associated with the contraception-fertility graph.

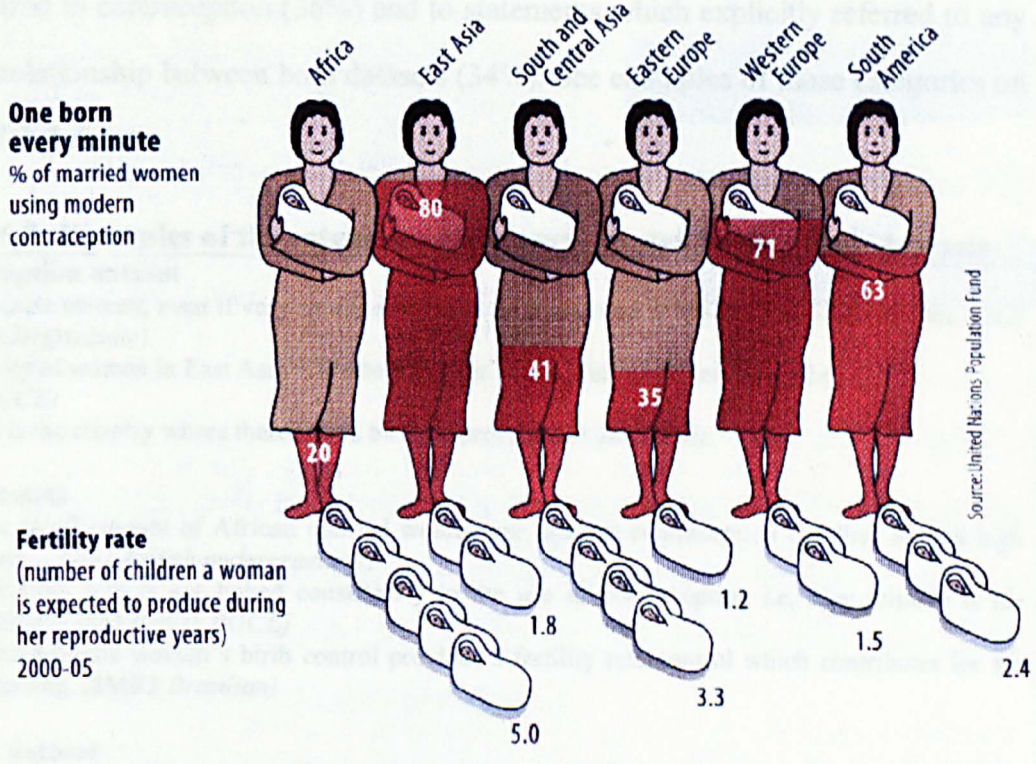
[1] Although it can be considered that the certain level of 'distortion' is inherent in all data interpretation.

6.4.1 Contraception-fertility graph statements

Among the British participants the average number of statements was 3 and among Brazilians the average was 2 per participant. However, all groups produced a similar number of positive and negative statements.

As commented in chapter 5, the contraception-fertility graph comprised two datasets (see Figure 6.1 below).

Figure 6.1: Graph reprinted from The World in 2002, The Economist, 2001, p.132



One dataset is related to contraception percentages and other to fertility rates. An initial coding of the participants' responses was made according to the main ideas of statements associated with the graph datasets.

The rationale of this categorisation was to identify whether the participants emphasised a specific graph dataset during their interpretation. Table 6.9 (below) presents those categories.

Table 6.9 – The frequencies of statements related to the contraception-fertility datasets

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Contraception dataset	75 (40%)	49 (32%)	82 (35%)	**206 (36%)**
Both datasets	67 (36%)	81 (54%)	49 (21%)	**197 (34%)**
Fertility dataset	37 (20%)	20 (13%)	41 (18%)	**98 (17%)**
Other data aspects	09 (4%)	01 (1%)	62 (26%)	**72 (13%)**
TOTAL	**188** (100%)	**151** (100%)	**234** (100%)	**573 (100%)**

The two most frequent categories were related to statements which emphasised the data related to contraception (36%) and to statements which explicitly referred to any type of relationship between both datasets (34%). See examples of those categories on Figure 6.2 (below).

Figure 6.2- Examples of the categories statements related to the graph datasets

Contraception dataset
(+) That some amount, even if very small, of modern contraception is available in all continents. *(2G1 British undergraduate)*
(+) Majority of women in East Asia + Western Europe use modern contraception. *(2A British PGCE)*
(-) Africa is the country where there is less birth control (5MG1 *Brazilian)*

Both datasets
(-) Only a small amount of African married women use modern contraception and they have a high fertility rate... *(7G2 British undergraduate)*
(-) The fertility rate is not linked consistently to the use of contraception i.e. how reliable is the contraception? (16M *British PGCE)*
(+) In East Asia the women's birth control provides a fertility rate control which contributes for the family planning. (8MR2 *Brazilian)*

Fertility dataset
(-) Fertility rates are surprisingly low in Eastern and Western Europe. *(8G3 British undergraduate)*
(+) The fertility rate in Africa is high. (1A *British PGCE)*
(-) The lowest fertility rate is in Eastern Europe. (8NS1 *Brazilian)*

Other aspects of the data
(+) As it is pictorial it does not seem so intimidating. (21G1 *British undergraduate*)
(-) Inequality that exists in modern advances across the world (e.g. medical advances giving women more freedom). (14A *British PGCE)*
(+) This research [is positive] because it approaches a very important topic which is not related to our country only. (12SN2 *Brazilian)*

The frequencies of the categories of participants' responses in Table 6.9 suggests that the number of participants who emphasised only the contraception dataset (36%) was approximately twice as high as those which mentioned only the fertility dataset

(17%). This frequency of responses might relate to the way in which the graph emphasised the contraception data (e.g. on the top dataset the pictures of women are larger then the babies' pictures on the bottom dataset which represent the fertility rates). However, the frequencies of responses for this categorization did not seem to provide evidence that the graphical form determined the way in which the participants interpreted the graph. For example, the majority of PGCE students' responses produced statements which were related to both datasets (54%).

These frequencies of responses provide different evidence from some studies conclusions which see the interpretation of graphs as being determined by the graphical form (e.g. Kosslyn, 1994; Tufte, 1997). For example, the fact that there was not great prevalence of one particular category presented on Table 6.9 suggests that the focalisation on a specific graph dataset did not seem associated with the visual configuration of the data.

Another attempt to identify trends among the participants' interpretations was made through the categorisation of their statements according to the explicit mention of geographical regions. The rationale of this categorisation was similar to the coding presented on Table 6.9. Therefore, it was intended to identify which elements from the data were utilised to compose the participants' interpretative statements. Table 6.10 (below) presents these categories of responses.

Table 6.10 – The frequencies of statements related to the regions displayed on the graph

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Mention of 1 region	76 (40%)	72 (48%)	105 (45%)	**253 (44%)**
No mention of any region	50 (27%)	45 (30%)	55 (23%)	**150 (26%)**
General mention of areas	47 (25%)	17 (11%)	49 (21%)	**113 (20%)**
Mention 2 or more regions	15 (8%)	17 (11%)	25 (11%)	**57 (10%)**
TOTAL	**188** (100%)	**151** (100%)	**234** (100%)	**573 (100%)**

The most frequent category (44%) was related to those sentences which mentioned one specific area displayed on the graph. Africa was the most mentioned area (48% of

those sentences). The other areas had the following percentages of frequency: Eastern Europe 23%; East Asia 22%; Western Europe 4%; and South America 3%.

However, the frequencies of other categories of responses suggest that a substantial number of participants produced statements which were not restricted to one area. They seemed to approach the information associated with geographical area globally.

Figure 6.3 (below) gives examples of this categorisation.

Figure 6.3: Examples of statements related to the regions displayed on the graph

Mention of one region
(-) That within Africa modern contraceptive methods are very low therefore the n° of children produced is rather high. (20G1 *British undergraduate*)
(+) East Asia high % of women are able to get hold of modern cont. (3A *British PGCE)*
(+) In Eastern Europe women use modern birth control, they are having only 1.2 children. (6TR2 *Brazilian)*

No mention of any region
(+) Generally the higher the %ge of women using contraception the lower the fertility rate i.e. contraception is working. (14G2 *British undergraduate*)
(-) Teaching of contraception is not effective or not had time to take effect yet. (9M *British PGCE)*
(-) The difference between birth control percentages is related to population's insufficient information. (7MG1 *Brazilian)*

General mention of areas
(+) In the two areas of highest % use of modern contraception being used in marriage, it appears to be working because there is a low birth-rate. (1G3 *British undergraduate*)
(+) All areas of the world are using contraception. (4M *British PGCE)*
(-) On the other hand, it can be seen that in poorer places women produce more children and in richer places are avoiding the births. (2MR2 *Brazilian)*

Mention two or more regions
(-) Poorer countries e.g. Africa, South + Central Asia have less women using modern contraception. (14G2 *British undergraduate*)
(-) That Africa, S + Central Asia + Eastern Europe have less than 50% use of contraceptives. (10A *British PGCE)*
(+) In East Asia and Western Europe the majority of women have access to health services and they use modern contraception. (17SN1 *Brazilian)*

Although the regions displayed were mentioned in the majority of sentences produced (54% of sentences mentioned at least one region displayed), it seemed that a variety of aspects might be influencing these responses. For example, from the frequencies of responses I could not confirm my expectation that British and Brazilian would respectively emphasise Western Europe and South America. Also I did not confirm my anticipation that a very large number of sentences would be related to Africa

which is normally associated with poverty and illiteracy. The expectations were based on the pilot study findings, and on the fact that all participants were involved in the education field (e.g. which is concerned with social issues) which would influence how they would see the data.

However, in order to examine the participants' consideration of the social context related to the data displayed on graph, I coded their responses in categories which are presented in Table 6.11 (below).

Table 6.11 – The frequencies of context considerations related to the data on the statements

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Social context of areas displayed	42 (23%)	48 (32%)	92 (39%)	**182 (32%)**
Vague consideration	52 (28%)	30 (20%)	57 (24%)	**139 (24%)**
No explicit consideration	42 (21%)	31 (21%)	06 (3%)	**79 (14%)**
Women-Child-Availability	24 (13%)	31 (20%)	23 (10%)	**78 (14%)**
"Countries" context	28 (15%)	11 (7%)	20 (9%)	**59 (10%)**
Socio-economical context	---	---	36 (15%)	**36 (6%)**
TOTAL	**188** (%)	**151** (100%)	**234** (100%)	**573 (100%)**

The most frequent category (32%) referred to those sentences which mention aspects of the context of areas displayed on the graph. See examples of this categorization on Figure 6.4 (below).

Figure 6.4: Examples of context considerations related to the data on the statements

Social context of areas displayed
(-) This [figures in Africa] could lead to population difficulties and also high levels of STD's. (13G1 *British undergraduate*)
(-) That Eastern Europe has a particularly low birth rate despite low contraceptive use suggesting problems in health. (10A *British PGCE)*
(+) In some countries where the majority of the population has very low income, birth control is working, for example, South America. (19SN2 *Brazilian)*

Vague consideration to context
(-) Women across Europe have a fairly low fertility rate compared to other continents. (13G2 *British undergraduate*)
(+) By using contraception, the population will increase gradually. (5M *British PGCE)*
(-) African women do not use birth control, that's why there is a high birth rate. (6TR2 *Brazilian)*

No explicit consideration to context
(+) Large total percentage of married women using modern contraception. (10G3 *British undergraduate*)
(+) 80% of East Asians use contraception. (11A *British PGCE)*
(+) The necessary birth control. (15MG1 *Brazilian)*

Women-Child-Availability
(+) In all of the continents at least 20% of married women have access to contraceptives so there is a degree of choice about pregnancy. (9G1 *British undergraduate*)
(-) Contraception possibly not widely available in some countries. (3A *British PGCE)*
(+) With birth control there is a decrease in the number of children which provides a control of problems such as criminality. (11SN2 *Brazilian)*

"Countries" context
(+) In East Asia 80% married women use modern contraception and have 'a more sustainable' average fertility rate than in Africa where only 20% mwmc [married women using modern contraception] and have a higher fertility rate. (15G2 *British undergraduate*)
(-) The countries with the lower use of contraception tend to be the less developed ones. (4A *British PGCE)*
(-) Due to the number of people in poor countries the level of unemployment will increase. (6MR2 *Brazilian)*

Socio-economical context
(+) The diversity of percentages is a consequence of the economical and political situation between continents. (18SN1 *Brazilian)*
(-) In countries with low incomes without birth control, and without basic infrastructure, the inhabitants' lives are at risk. (2MG1 *Brazilian)*

The frequencies of participants' responses presented on Table 6.11 indicated that the vast majority of statements (62%) contained an explicit reference to contextual aspects related to the data (social context of geographical areas; women and children's lives; availability of contraception and socio-economical context of areas). Approximately 24% of the sentences contained a vague consideration of the social context which the data could be related. A low percentage (14%) of statements did not mention other information related to the data displayed. These frequencies also suggested that the participants' sentences were not directly related to what was displayed on the contraception-fertility graph.

These frequencies suggest that the majority of participants were not restricted to the data displayed on graph when they were producing their statements. They added to their sentences other previous knowledge and opinions related to the data.

Another coding of the participant's responses was related to mathematical knowledge involved in their statements, using categories which were associated with numerical or quantitative elements. Table 6.12 (below) presents the frequencies of those categories.

Table 6.12 – The frequencies of numerical-quantitative elements on the statements

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Extreme figures	78 (41%)	64 (42%)	82 (35%)	**224 (39%)**
No explicit numerical relationship	39 (21%)	36 (24%)	84 (36%)	**159 (28%)**
General statement about the figures	26 (13%)	17 (11%)	34 (14%)	**77 (13%)**
Relationship contraception-fertility	29 (15%)	22 (14%)	25 (11%)	**76 (13%)**
Contradiction in East Europe	16 (9%)	12 (8%)	09 (4%)	**37 (6%)**
TOTAL	**188** (100%)	**151** (100%)	**234** (100%)	**573 (100%)**

The most frequent category of responses (39%) was related to those sentences which emphasised the 'extreme' figures, the higher and lower values displayed on the graph. See examples of this coding on Figure 6.5 (below).

Figure 6.5: Examples of numerical-quantitative relationship on the statements

Extreme figures
(-) Rates of married women using modern contraception in less developed continents are low. (8G3 *British undergraduate*)
(-) That Africa, S + Central Asia + Eastern Europe have less than 50% use of contraceptives. (10A *British PGCE)*
(+) Eastern European women mainly control the fertility rate. (18MG1 *Brazilian)*

No explicit numerical relationship
(+) Modern contraception is being used to prevent unwanted births in many areas of the world. (4G1 *British undergraduate*)
(-) Contraception possibly not widely available in some countries. (3A *British PGCE)*
(+) The graph shows that some women have control of their children's birth. (7TR2 *Brazilian)*

General statement about the figures
(+) Most married women are able to have children.(14G2 *British undergraduate*)
(+) All areas of the world are using contraception. (4M *British PGCE)*
(-) The poor countries or developing countries present high birth rates yet, there the majority of women do not use modern contraceptive methods. (15MR2 *Brazilian)*

Relationship contraception-fertility
(-) In Africa the majority of women are not using modern contraception and an average produce 5 children which is a lot of children to feed and look after. (3G3 *British undergraduate*)
(-) Due to the low % of women in Africa not using contraception the fertility rate is greater than the other continents represented. (12A *British PGCE)*
(+)I think in Western Europe and South America the birth control and fertility rate is balanced. (4SN2 *Brazilian)*

Contradiction in East Europe
(-) Women in Eastern Europe do not seem to be using a high % of contraception but yet have a low birth rate. (15G1 *British undergraduate*)
(-) Contraception is not the only influence on fertility rates for example in Europe both contraception and fertility rates are low. (3M *British PGCE)*
(+) Although in Eastern Europe the percentage of married women using modern contraception is low the number of children is also low. (11NS1 *Brazilian)*

The categories displayed on Table 6.12 also suggest that even though 13% of statements made reference to the contraception-fertility relationship only 6% of sentences explicitly referred to the contradiction in Eastern Europe. This might be an indication that the majority of participants did not observe this aspect of the graph when they were producing the statements.

The categorisation of the participants' sentences presented in this section gives an indication of elements related to *critical sense* in interpretation of media graphs. For example, although the majority of the participants tended to base their sentences on aspects of data displayed on the contraception-fertility graph they were not restricted to this data.

Therefore the participants considered the numerical-quantitative categories displayed but they also added to their sentences other previous knowledge and opinions associated with the data. However, the use of their knowledge related to the graph seemed to be complex and the data collected from the questionnaire was not enough to investigate such aspects.

In addition, even though I was looking at patterns associated with the participants' sentences, I also recognise aspects of their sentences which made each statement relate to a unique interpretative process. For example, the mention of a specific piece of data from the contraception-fertility graph does not necessarily mean that they perceived this data in the same way.

The following subsection presents the questions formulated by the participants and discusses other aspects related to elements of *critical sense* in the participants' interpretation of contraception-fertility graph.

6.4.2 Contraception-fertility graph questions

The third item of the contraception-fertility task invited the participants to ask questions about that media graph. The average number of questions produced for both British and Brazilian groups was 2 questions per participant.

Similar categorisation applied to the participants' sentences was utilised to analyse their questions. However, some codes were different because the participants' questions revealed particular aspects which were not present among their statements.

Table 6.13 (below) presents the frequencies of the sentences in relation to the graph datasets.

Table 6.13 – The frequencies of questions related to the graph datasets

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Other aspects of the data	65 (44%)	67 (49%)	86 (42%)	**218 (45%)**
Contraception dataset	29 (20%)	17 (13%)	29 (14%)	**75 (15%)**
Features of graph	14 (9%)	12 (9%)	48 (23%)	**74 (15%)**
Both datasets	17 (11%)	20 (15%)	25 (12%)	**62 (13%)**
Fertility dataset	23 (16%)	19 (14%)	18 (9%)	**60 (12%)**
TOTAL	**148** (100%)	**135** (100%)	**206** (100%)	**489 (100%)**

The most frequent category of questions (45%) referred to other aspects which were not displayed on the graph. It can be observed that only 15% of the questions were addressed to particular features of the graph.

The comparison between the frequencies of statements (see Table 6.9) and questions related to the graph datasets suggest different patterns. The majority of participants' statements were directly related to graph datasets (87%) while similar types of questions represented 40%. Therefore, a large percent of participants questions indicated that they would like to know more about particular aspects of the graph which were not displayed. Figure 6.6 (below) gives examples of this questions' category.

Figure 6.6: examples of questions related to the graph datasets

Other aspects of the data

- Why is North America not included? (12G2 *British undergraduate*)
- How many abortions take place in these countries? (15M *British PGCE)*
- How many and which countries comprise the research? (7TR2 *Brazilian)*

Contraception dataset

- Is the % of married women using contraception static? (22G1 *British undergraduate*)
- Is data collection equally reliable throughout the word [world]? Surely European/Western women are more open about contraceptive use than women elsewhere. (5A *British PGCE)*
- Why the subtitle "one born every minute" (it confuses me instead of clarifying). (13MG1 *Brazilian)*

Features of graph

- Why did they use pictures of babies rather a clear graph which shows the points. (1G3 *British undergraduate*)
- Why is there no key to the fertility rate part of the graph explaining what each picture of a baby represents? (6M *British PGCE)*
- Do you believe that a graph so different from others help its interpretation? (5MR2 *Brazilian)*

Both datasets

- Why is the fertility rate low among Eastern European women? But the percentage of women using contraception is also low? (11G2 *British undergraduate*)
- Do they have the data for fertility rate of contraception users and fertility rate of non-contraception users? (6A *British PGCE)*
- Why in Africa the percentage 20% is similar to the Eastern Europe (35%) but the fertility rates are so different? (11NS1 *Brazilian)*

Fertility dataset

- Is the number of children produced the same as the number of pregnancies? (22G1 *British undergraduate*)
- What are productive years? (10M *British PGCE)*
- Why did you limit the fertility rate to the number of children which is expected rather than actual number? (9MG1 *Brazilian)*

The categorisation related to the occurrence of questions which mentioned 'areas' displayed on the graph is shown on Table 6.14 (below).

Table 6.14 – The frequencies of questions related to the regions displayed on the graph

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
No mention of regions displayed	113 (76%)	85 (63%)	152 (74%)	**350 (72%)**
Generic mention to 'areas'	17 (11%)	27 (20%)	22 (10%)	**66 (13%)**
Mention of one area	14 (9%)	16 (12%)	26 (13%)	**56 (11%)**
Mention of 2 or more regions	04 (3%)	07 (5%)	06 (3%)	**17 (3%)**
TOTAL	**148** (100%)	**135** (100%)	**206** (100%)	**489 (100%)**

The vast majority of the questions (72%) did not mention any region displayed on the graph. A number of questions (13%) asked about generic aspects of the areas displayed on the graph. Figure 6.7 presents example of this categorisation.

Figure 6.7: Examples of questions related to the regions displayed on the graph

No mention of regions displayed

- How did you elicit the information? (2G3 *British undergraduate*)
- Does "expected to produce during her reproductive years" change? (9A *British PGCE)*
- What are the ages of these women? (10SN2 *Brazilian)*

Generic mention to 'areas'

- Are women aware of contraception in poorer regions?(8G1 *British undergraduate*)
- Is it trying to suggest that women in regions where fertility rate is high are using modern contraception less often? (11M *British PGCE)*

- I would ask questions whose answers make explicit the culture of regions like Africa. (11MR2 *Brazilian)*

Mention of one area

- A bit deceiving (sic), does this mean women in Eastern Europe are not having as much sex within marriage? (1G3 *British undergraduate*)
- What is the average no. of children in Africa per family, surviving to the age of 10? (6A *British PGCE)*
- In Eastern Europe only 35% of women use or do birth control, despite this why do they have 1.2 children? (7MG1 *Brazilian)*

Mention of 2 or more regions

- Why is it that in Eastern Europe they produce less (sic) babies than East Asia, yet they use 45% less contraception? (5G2 *British undergraduate*)
- Do you know how fast the population growth is in Africa compared to East Asia? (18M *British PGCE)*
- The big question is related to Eastern Europe which is higher than Africa and it has a low fertility rate. (14SN1 *Brazilian)*

The categorisation related to the mention of regions displayed on the graph also suggested different tendencies for the statements and questions produced. Approximately 54% of the participants' statements were explicitly related to data associated with one or several regions displayed on the graph (See Table 6.10). However, only 14% of questions were categorised with this code.

The categories associated with questions which made reference to the origin of the data also seemed to have a different pattern compared to the same categorisation of statements (see Table 6.11). A higher percentage of participants' written questions were related to the context of women, children or availability of contraception. It seems that the questions asked were more related to specific aspects of the graph data than were the statements.

Although the participants were invited to "judge" positively and negatively the data displayed in their statements seemed to be a description of the data. On the other hand, the third item invited the participants to be in a questioning attitude. The different role suggested by this task item seemed to influence the composition of the participants' interpretations indicated by their written questions. For example, they produced a large number of questions not restricted to aspects displayed on the contraception-fertility graph.

On the other hand the participants' questions seemed to be less related to social context issues which involved the data displayed on contraception-fertility graph. Table 6.15 (below) indicates that the frequency of questions related to the social context was 53% while 62% of the participants' statements were associated with this particular aspect (see Table 6.11).

Table 6.15 – The frequencies of questions which considered the context of the data

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Women-children-availability	50 (34%)	44 (33%)	49 (24%)	**143 (29%)**
Vague consideration	72 (48%)	37 (27%)	32 (15%)	**141 (29%)**
No explicit consideration	10 (7%)	19 (14%)	61 (30%)	**90 (18%)**
Context of areas displayed	12 (8%)	15 (11%)	27 (13%)	**54 (11%)**
Other socio-cultural factors	---	12 (9%)	26 (13%)	**38 (8%)**
Countries' context	04 (3%)	08 (6%)	11 (5%)	**23 (5%)**
TOTAL	**148** (100%)	**135** (100%)	**206** (100%)	**489 (100%)**

On the other hand it can be observed on Table 6.15 that the percentage of questions which had a vague or non-explicit reference to the context of data (47%) was higher than the similar type of statements (38%) as can be seen on Table 6.11.

Figure 6.8 (below) presents examples of this categorisation of questions.

Figure 6.8: Examples of questions which considered the context of the data

Women-child-availability context

- What is the mortality rate for children in each country? (24G1 *British undergraduate*)
- Why are you using only married women? (12A *British PGCE)*
- How can I make sure that the women are using a birth control method? (6TR2 *Brazilian)*

Vague consideration of context

- Why does it not represent all areas of the world? (4G2 *British undergraduate*)
- Is there any evidence connected to [this] data to suggest that this forecast was correct? (21M *British PGCE)*
- What were your difficulties in carrying out this data collection? (4SN2 *Brazilian)*

No explicit consideration about context

- Why have the numbers of babies drawn been rounded up? (e.g. South + Central Asia 3.3 children has been represented by 4 babies whereas eastern Europe, 1.2 has been represented by only 1 baby). (3G3 *British undergraduate*)
- Why is there no key to the fertility rate part of the graph explaining what each picture of a baby represents? (6M *British PGCE)*
- Why not represent the data in a simpler graph which make easier to interpret it? (2NS1 *Brazilian)*

Context of areas displayed

- Are the 20% of women in Africa who use contraception rich? 8G1 *British undergraduate*)
- Are the figures for East Asia distorted by government laws restricting the number of children allowed to be born to a family (e.g. China)? (5A *British PGCE)*
- How in Eastern Europe despite a very low birth control percentage, do women have a very low fertility rate? (24MR2 *Brazilian)*

Other socio-economical factors

- What about cultural factors affecting higher fertility rates? This is quite unclear to me! (11M *British PGCE)*
- What is the relationship between the social levels of those women? Because there is an economical diversity among the countries researched. (4MG1 *Brazilian)*

Countries' context

- What is the average life expectancy in these countries? (14G1 *British undergraduate*)
- Does the data represent whole population areas or is it limited to city only? (23A *British PGCE)*
- Whether this research particularly considered the numbers of each country or it was a general approach involving the continent as whole? (5TR2 *Brazilian)*

Finally, the questions were also categorised according to the numerical or quantitative aspects presented. Table 6.16 (Below) shows the codes associated with this categorisation.

Table 6.16 – The frequencies of numerical-quantitative relationships on the questions

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Questioning the data collection	43 (29%)	27 (20%)	63 (30%)	**133** (27%)
Questioning other variable effect	54 (36%)	64 (47%)	13 (6%)	**131** (27%)
Questioning the graphical representation	21 (14%)	18 (13%)	58 (28%)	**97** (20%)
Questioning purpose or category of the graph	21 (14%)	16 (12%)	16 (8%)	**53** (11%)
Questioning contradiction in Eastern Europe	09 (6%)	10 (7%)	12 (6%)	**31** (6%)
No explicit numerical relationship	---	---	28 (14%)	**28** (6%)
Other numerical relationship	---	---	16 (8%)	**16** (3%)
TOTAL	**148** (100%)	**135** (100%)	**206** (100%)	***489*** (100%)

The three more frequent categories of questions are related to technical aspects of the data: data collection, effects of other variables, and graphical representation. The frequencies of these three categories together represented 74% of all questions produced.

Figure 6.9 (below) presents examples of this categorisation.

Figure 6.9: Examples of numerical-quantitative relationships on the questions

Questioning the data collection

- How certain are they that the above data is accurate? (4G2 *British undergraduate*)
- How was the research conducted? (4M *British PGCE)*
- What were the economic and schooling levels of people? (7TR2 *Brazilian)*

Questioning other variable effect

- What about the % of unmarried women using contraception? (13G3 *British undergraduate*)
- Why has he limited it to only married women when in the West marriage is not as strongly related to child birth as before? (1M *British PGCE)*
- Whether they considered cultural issues of the places researched? (20SN2 *Brazilian)*

Questioning the graphical representation

- Why did you use pictures instead of a line graph? (14G1 *British undergraduate*)
- Yes, I would question the use of the baby figures in a '3D bar chart' effect. (16A *British PGCE)*
- I would ask about the graphical form, it is very confused. (16SN1 *Brazilian)*

Questioning purpose of a category of the graph

- What is deemed as 'modern' contraception? (8G3 *British undergraduate*)
- What is the purpose of this graph? It is quite confusing to interpret. (11M *British PGCE)*
- I composed regarding the significance of "One born every minute" is this a world statistic? (23A *British PGCE)*
- Why didn't you put the % of married women more explicitly on the graph? This way I can't understand very well. (3TR2 *Brazilian)*

Questioning contradiction in Eastern Europe

- Why in Eastern Europe do only 35% of married women use contraception yet they have the lowest fertility rate? (2G1 *British undergraduate*)
- Why is the lowest fertility rate found with the second lowest percentage of women using contraception? (13M *British PGCE)*
- Why in Eastern Europe 35% of women use modern birth control and average of children is 1.2 when in South America even though this control is 63%, the rate is higher (2.4 children)? (5MG1 *Brazilian)*

No explicit numerical relationship

- Why use that graph if it cannot be utilised to help the countries? (19SN2 *Brazilian)*

Other numerical relationship

- Do you think that in future the control will increase in under-developing countries? (1MG1 *Brazilian)*

The analyses of the participants' sentences and questions revealed the involvement of elements related to the notion of *critical sense* in interpretation of media graphs. Therefore, I could identify that the participants used their mathematical knowledge about graphs and also brought their knowledge and opinions about the social context to which the data might be related. My analyses suggest that particularly the participants' responses for the third item related to the contraception-fertility task took the form of sceptical questions in relation to the graphical representation.

However, based on my analysis of the participants' statements I could not confirm previous expectations such as distinct patterns for British and Brazilian's responses. I believe that the process of interpretation seemed associated with a complex range of elements which does not allow the establishment of 'simple' connections between variables such as the background of participants and their responses (e.g. Brazilians could have emphasised the South America figures more than the British participants).

Although in subsections 6.4.1 and 6.4.2 I presented a wider picture of the participants' responses, I recognise that each participant's answer could be related to a personal view of the data displayed on the graph. For example, although two participants have written statements which focused on "women's choices about contraception" the interpretative process which motivates their use of the term *choice* could be different for each participant. However, the nature of task did not allow me to investigate in depth these aspects of the participants' interpretations.

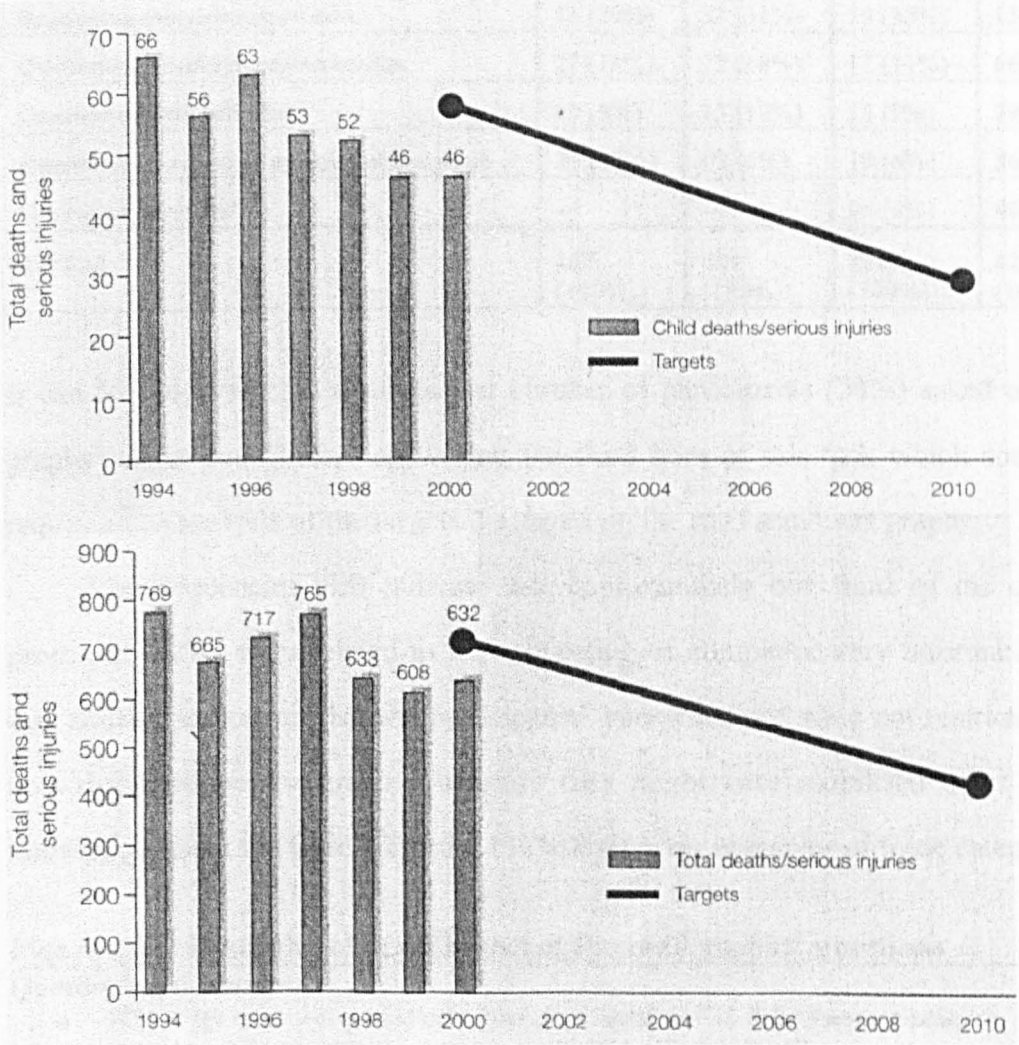
I also believe that other factors within data collection instrument also contributed to a partial exam of the participants' interpretations. For example, in order to complete the questionnaire the participants could write only a few elements of their interpretation of the contraception-fertility graph.

In the following section I discuss the participants' answers to the items related to the items of the road accidents graphs tasks.

6.5 Responses to road accidents graph items

The road accidents graphs task was composed of three items. The first item invited the participants to ask questions directed at the producer of graphs (which was exactly the same as the third item of the contraception-fertility graph). The second item asked participants to combine the information from both road accident graphs (see Figure 6.10 below) in one graph. The third item asked how realistic the targets displayed on the graphs were. The following subsections (6.5.1; 6.5.2; and 6.5.3) will describe the responses given by the participants for each item of the road accidents graphs task.

Figure 6.10: graphs reprinted from *Quality of life in Warwickshire*, 2001, 93-94



6.5.1 Road accidents graph questions

The average number of questions produced for the first item of the road accidents tasks graphs task was 2 per person for most of groups. Table 6.17 (below) shows the categorisation of the participants' responses related to the main aspects of the questions produced.

Table 6.17 – Main aspects of the road graphs questions

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Questioning the targets	49 (33%)	40 (33%)	54 (35%)	**143** (34%)
Requesting complementary data	43 (29%)	37 (31%)	54 (35%)	**134** (32%)
Questioning graphical representation	27 (18%)	22 (18%)	17 (11%)	**66** (16%)
Questioning data collection	09 (6%)	15 (12%)	15 (9%)	**39** (9%)
Questioning purpose or category of the graph	19 (13%)	07 (6%)	10 (6%)	**36** (8%)
"I have no questions"	---	---	06 (4%)	**06** (1%)
TOTAL	**147** (100%)	**121** (100%)	**156** (100%)	**424** (100%)

It can be observed that a substantial number of participants (34%) asked about the graphs' target even before answering the third item of this task which specifically requested an analysis of the targets displayed on the road accidents graphs.

The frequencies also indicate that approximately one third of the questions produced (32%) were related to the requesting of complementary information. This was another indication that the participants' interpretations were not restricted to the data displayed on the graph. Therefore they might have mobilised other previous knowledge about the topic. Figure 6.11 (below) gives examples of these categories.

Figure 6.11: Examples of main aspect of the road graphs' questions

Questioning the targets

- Why is the target not to eradicate Road Accidents? (ArG1 *British undergraduate*)
- How/why did you set the targets observed? (25Ar *British PGCE)*
- Which measures will be taken based on this information to reach the target for 2010? (21SN2 *Brazilian)*

Requesting complementary data

- How many were deaths and how many were serious injuries? (1rG2 *British undergraduate*)
- Were there any particular contributing factors to the increase in road deaths in 1997 such as particularly bad weather? (25Mr *British PGCE)*
- What are the geographical characteristics of Warwick region? (9NS1 *Brazilian)*

Questioning graphical representation

- Why is the target line drawn (sic) higher than the actual death/injury number for 2000? (3rG3 *British undergraduate*)
- Why use a scale of 100's in first graph when dealing with numbers such as 717 and 606? (2Ar *British PGCE)*
- Whether it is necessary to put imprecise numbers at the side (in the total of deaths/serious injuries) because at the top of each bar there is precise number of victims? (5MR2 *Brazilian)*

Questioning purpose of a category of the graph

- What was the purpose of producing this graph? (7rG2 *British undergraduate*)
- What do you classify as a serious injury? (1Mr *British PGCE)*
- What was your motivation which lead you to research and produce this graph? (19SN2 *Brazilian)*

Questioning the data collection

- How did they gather the information? (5rG1*British undergraduate*)
- How accurate is the data? (3Ar *British PGCE)*
- How did you produce those numbers?(4TR2 *Brazilian)*

6.5.2 Drawing a graph which combined the data from road accidents graphs

The second item of the road accident graph task asked about the shape of a hypothetical graph which would combine the data from both road accidents graphs (see Figure 6.11 below).

Participants were asked to draw or to make a sketch of the graph rather than a formal production. Therefore, the rationale of this item was to provide another type of opportunity in which the participants could approach the data from both graphs in more detail rather than evaluate their skills in constructing a graph.

Although the rationale was not to assess the construction of graphs as in other studies (e.g. Mevarech and Kramarsky, 1997) the responses for this item provided some indications of participants' understanding about the data as well as their specific statistical relationships in the graphical representation (Chick, 2004).

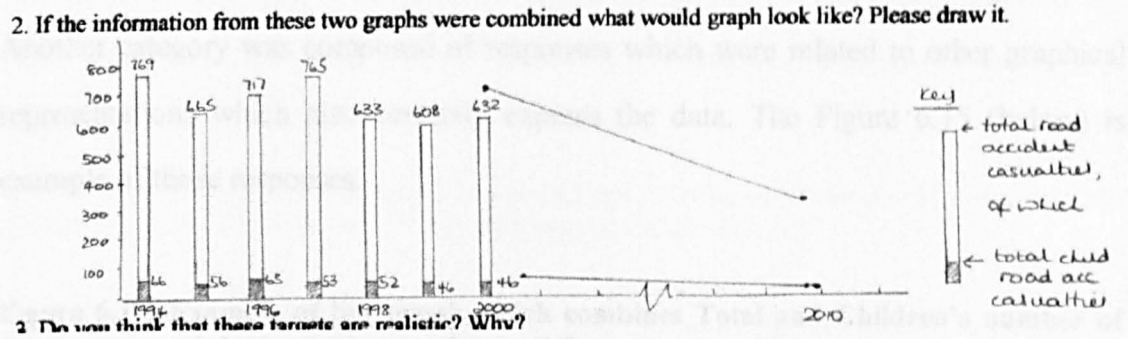
Table 6.18 (below) presents the frequencies of categories related to participants' responses.

Table 6.18 – Frequencies of responses for the *combining of data in one graph* item per group

Categories related to graphs produced as combination of data (item 2 of road accidents graph)	British Undergr.	British PGCE	Brazilian Undergr.	TOTAL
Bar graph of Total with indication of Children in each bar	15 (23%)	27 (51%)	17 (17%)	**59** (27%)
Bar graph with specific bars for Total and Children	17 (27%)	07 (13%)	22 (22%)	**46** (21%)
Bar graph of Total without indication of Children	12 (19%)	09 (17%)	25 (25%)	**46** (21%)
Did not draw any graph or sketch	01 (1%)	01 (1%)	27 (27%)	**29** (13%)
Other responses with graphical representations	13 (20%)	05 (9%)	02 (2%)	**20** (9%)
Drew graphical representations with "mistakes"	06 (9%)	05 (9%)	07 (7%)	**18** (8%)
TOTAL	**64** (100%)	**54** (100%)	**100** (100%)	**218** (100%)

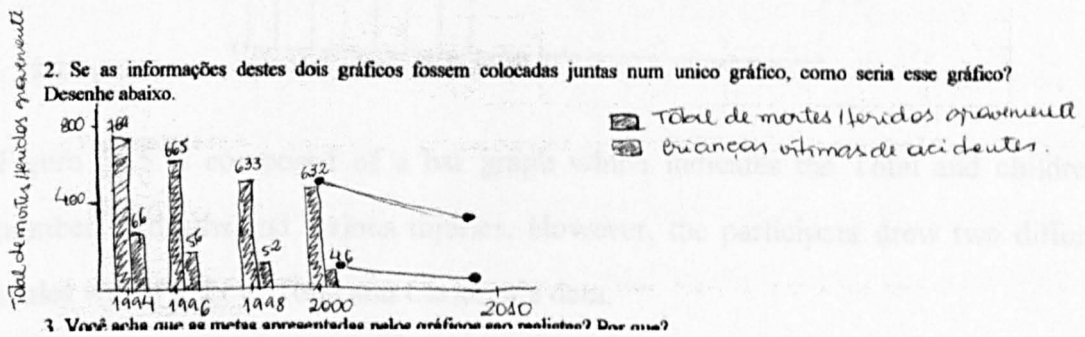
The most frequent category was comprised of participants' responses with bar graphs similar to the Total Road accidents (see Figure 6.11) which indicate the number of children's deaths and serious injuries. As can be observed on Table 6.18 the majority of British PGCE students (51%) produced this type of response. Figure 6.12 (below) is an example of this category of response.

Figure 6.12: Example of bar graph of Total number of deaths-serious injuries with indications Children's figures in each bar which was drawn by a British PGCE participant (A24 - Joy)



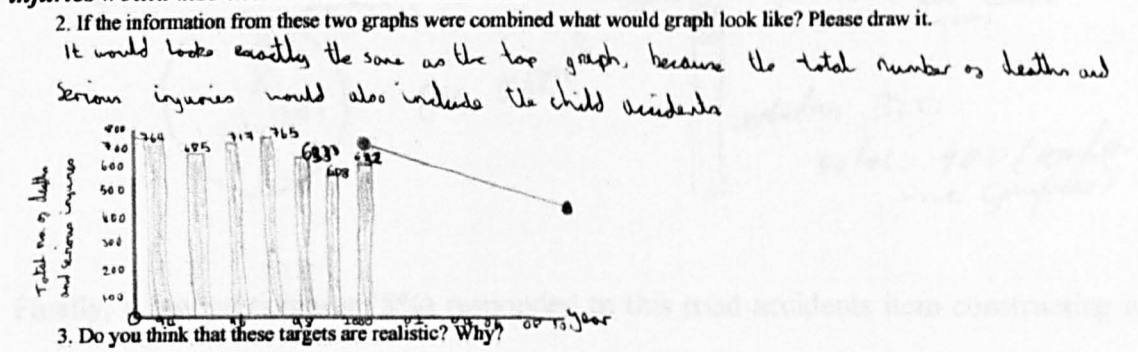
The second most frequent type of response suggested the construction of bar graphs which were composed of specific bars for total numbers of death and serious injuries and numbers related to children. Figure 6.13 (below) gives an example of this type of response.

Figure 6.13: Example of bar graph with specific bars for Total and Children which was drawn by a Brazilian undergraduate participant (19BM1)



Another frequent type of category (21%) was related to those responses which indicated the graph would look like exactly the same the 'first graph' (Total number of deaths and serious injuries). Figure 6.14 (below) is an example of this type of response.

Figure 6.14: Examples of bar graph of Total without indication of Children which produced by a British undergraduate (14G1 – Alex):
"It would look exactly the same as the top graph, because the total number of death and serious injuries would also include the child accidents"



Another category was composed of responses which were related to other graphical representations which also correctly express the data. The Figure 6.15 (below) is example of those responses.

Figure 6.15: Example of bar graph which combines Total and Children's number of deaths-serious injuries with use of two different scales which as drawn by a British undergraduate (8G2 - Max)

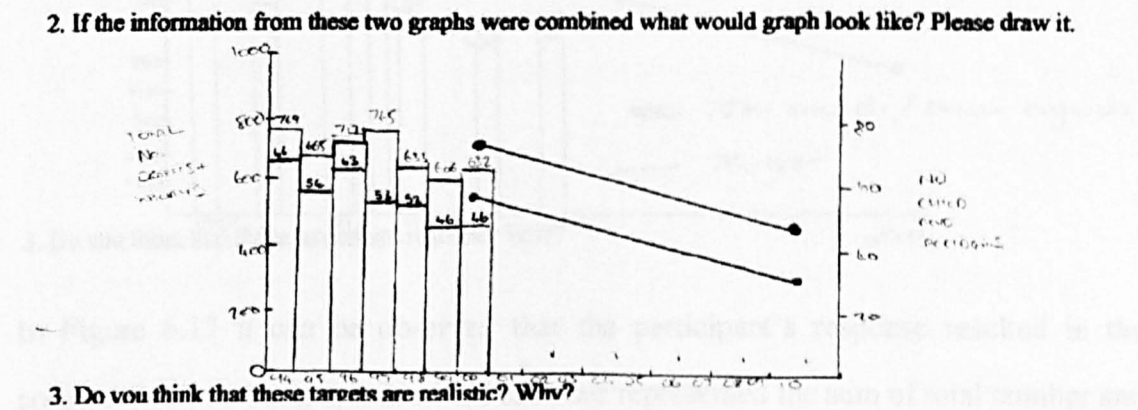
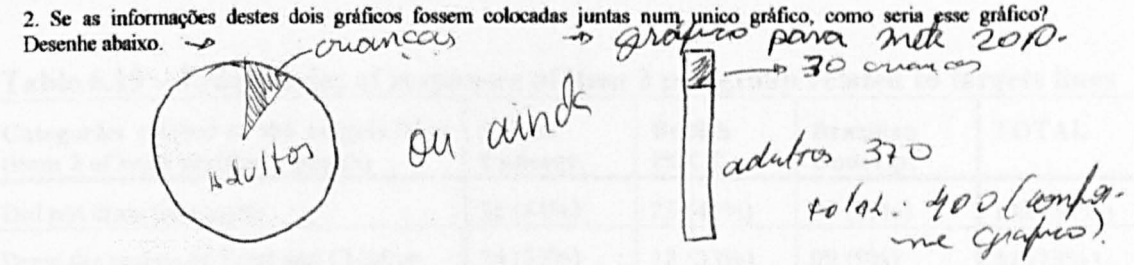


Figure 6.15 is composed of a bar graph which indicates the Total and children's number of deaths and serious injuries. However, the participant drew two different scales which refer to Total and Children's data.

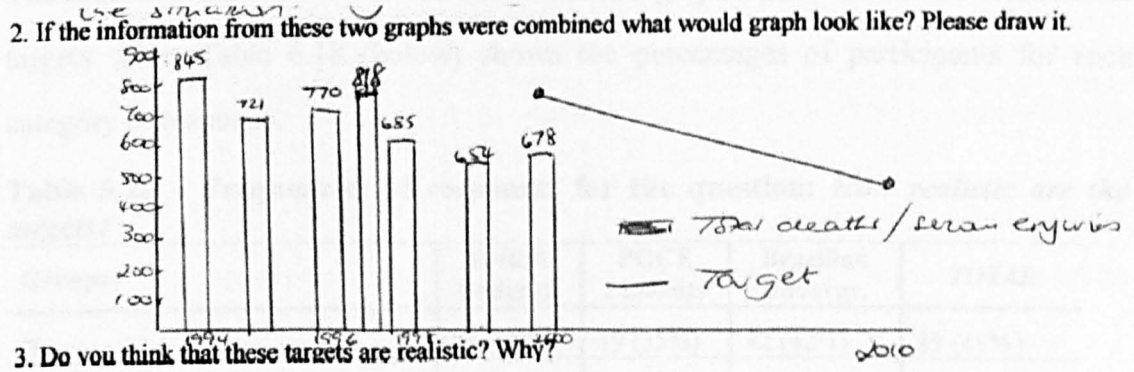
Another example of the same category is given in Figure 6.16 (below). The participant illustrated her answer with two possibilities of graphical representation.

Figure 6.16: Example of two different types of graphs given by a Brazilian undergraduate (17BN2)



Finally, a few participants (8%) responded to this road accidents item constructing a graph which did not give an accurate understanding of the relationship between the data which came from both graphs. Figure 6.17 (below) is an example of this type of response.

Figure 6.17: Example of responses which did not give an accurate combination of data which was drawn by a British PGCE participant (A26 – Diana)



In Figure 6.17 it can be observed that the participant's response resulted in the construction of a bar graph in which each bar represented the sum of total number and children's number of deaths and serious injuries. In that case, the participant did not realise that the total number of casualties already contained the children's figures.

The analysis of graph type used by the participants revealed that approximately 80% of participants responded to this item with a bar graph example. Among all participants 6% drew line graphs and only one student gave an example of a pie chart.

Some participants did not draw any graph or sketch. This category represented 27% of the total of responses among Brazilian students. Among British students two participants did not complete the second item of the road accidents graph.

The majority of responses to this road accidents graph item (56%) did not give explicit consideration to the target (see Table 6.19 below).

Table 6.19 – Frequencies of responses of item 2 per group related to targets lines

Categories related to the targets lines (item 2 of road accidents graph)	British Undergr.	British PGCE	Brazilian Undergr.	TOTAL
Did not draw the targets	26 (41%)	23 (43%)	73 (73%)	**122 (56%)**
Drew the targets of Total and Children	24 (37%)	18 (33%)	09 (9%)	**51 (23%)**
Drew the target of Total only	14 (22%)	13 (24%)	18 (18%)	**45 (21%)**
TOTAL	**64** (100%)	**54** (100%)	**100** (100%)	**218 (100%)**

Table 6.19 shows that that 23% of participants considered both targets, and only 21% made reference to the reduction target of total number of deaths and serious injury.

6.5.3 Analysing road accidents graphs' targets

The third item associated with the road accidents graphs asked about how realistic the targets were. Table 6.18 (below) shows the percentages of participants for each category of response.

Table 6.20 – Frequencies of responses for the question: *How realistic are the targets?*

Groups	British Undergr.	PGCE Students	Brazilian Undergr.	*TOTAL*
No	28 (44%)	19 (35%)	42 (42%)	**89 (41%)**
Depends - hard to say	14 (22%)	19 (35%)	24 (24%)	**57 (26%)**
Yes	11 (17%)	04 (7%)	14 (14%)	**29 (13%)**
Did not answer	04 (6%)	06 (11%)	09 (9%)	**19 (9%)**
No Total–Maybe Children	07 (11%)	06 (11%)	05 (5%)	**18 (8%)**
Other meaning 'realistic target'	---	---	06 (6%)	**6 (3%)**
TOTAL	**64** (100%)	**54** (100%)	**100** (100%)	***218 (100%)***

Most of the participants responded that the targets were not realistic (41%). An uncertain answer (e.g. *it depends* or *maybe children's target seems realistic*) represented 34% of all answers. A small percentage of participants answered that the target were realistic (13%), or did not give any answer (9%). See examples of the participants' responses in Figure 6.18 (below).

Figure 6.18: Examples of responses for the question: *How realistic are the targets?*

No

- No. The line for the targets is much steeper than the overall trend from previous years. (3rG3 *British undergraduate*)
- No - Not at the current rate of decline (which has been much more gradual in 6 years. (20Mt *British PGCE)*
- No, because the graphs do not infer a deep decrease on the number of accidents' victims as is indicated by the target for 2010. (21MG1 *Brazilian)*

Depends - hard to say

- Difficult to assess as many external factors will have a direct effect up on targets. (18rG3 *British undergraduate*)
- Hard to tell, depends what preventive measures are put in place. (19Mt *British PGCE)*
- I can't say because I don't know how reliable the data collection was. (27RM2 *Brazilian)*

Yes

- Yes, by increasing awareness to road safety road accidents can become lower as seen in child road accident since 1994. It's impossible to stop all road accidents because accidents do happen. (ArG1 *British undergraduate*)
- Yes, they are in line with the recent trends. (5At *British PGCE)*
- Yes, because after some years this expected target can be modified. (5TR2 *Brazilian)*

No Total–Maybe Child

- I think they are quite dramatic declines in accidents could be realistic for child road accidents as they have been declining since 1997 (through safety campaigns etc). Maybe a bit much to ask for all accidents as they haven't been on a steady decrease. In fact, the numbers increased from 1999-2000. There needs to be proof that something is being done to prevent accidents. (12rG1 *British undergraduate*)

Other meaning 'realistic target'

- Yes, because people do not pay much attention on the traffic. (1NS2 *Brazilian)*
- Yes, because even though there are many educational campaigns the accidents and death rates continue increasing. (26RM2 *Brazilian)*

Another categorisation of the participants' answers for item 3 was related to the analysis of justifications for their answers. Table 6.19 (below) presents the percentages of participants for each type of justification.

Table 6.21 - Main aspect on which the answer about targets was based

	British Undergr.	PGCE Students	Brazilian Undergr.	TOTAL
Based on opinion	20 (31%)	21 (39%)	59 (59%)	**100 (46%)**
Based on the graphs	23 (36%)	19 (35%)	26 (26%)	**68 (31%)**
Both graph - opinion	17 (27%)	08 (15%)	06 (6%)	**31 (14%)**
Did not answer	04 (6%)	06 (11%)	09 (9%)	**19 (9%)**
TOTAL	**64 (100%)**	54 (100%)	**100** (100%)	**218 (100%)**

The most frequent type of justification was based on participants' opinion (46%). This category represented the majority of Brazilian participants' justifications (59%).

Figure 6.19 (below) gives examples of this coding.

Figure 6.19: Examples of main aspect on which the answer about targets was based

Based on opinion

- No I don't think that these targets are realistic as road traffic is increasing. However people are becoming more aware of road safety. Personally I think that they could possibly decrease but only minimally. (20rG1 *British undergraduate*)
- I think they are optimistic as the volume of traffic on the road increases unfortunately the number of fatalities will not decrease. Moreover, the targets by 2010 are very ambitious. (22Mt *British PGCE)*
- No, because estimations are never real data. (16MR2 *Brazilian)*

Based on the graphs

- If the targets line is extended over the previous years on the graph then the number of deaths and serious injuries has decreased on a similar gradient to the target line. (6rG3 *British undergraduate*)
- They would appear so, as there is a general downward trend in both graphs and they are already below the present target. (8At *British PGCE)*
- Maybe it is not too easy, because the rates have been almost constant. (11MG1 *Brazilian)*

Both graph – opinion

- Yes, they are the same as the gradient between 1994 figures and 2000. No, it is unlikely that road accidents could ever be as low as in 2010 unless people change the way they drive and don't walk onto roads. (15rG2 *British undergraduate*)
- The child one might be real because since 1996 the rate is reducing, however the target should start from 46 [in 2000] rather 56. The total one, measures must be taken to make the population aware and then the rates would decrease each year. (19MR2 *Brazilian)*

The responses related to item 1 seemed to motivate the production of questions which addressed specific aspects of the data displayed (e.g. the targets) as well as the absence of other elements (e.g. requesting of complementary data). These frequencies were similar to questions asked in relation to the contraception-fertility graph task.

The responses associated with item 2 of the road accidents graphs task gave evidence that only a few participants did not understand numerical-quantitative relationships from the graphical representation.

It could be observed from the frequencies of responses related to item 3, that other aspects of participants' sceptical approaches to the data were displayed by the high percentages of responses which did not consider the targets realistic. Generally, the frequencies of British participants' responses considered more aspects of the

graphical representation (63% of the responses among the PGCE's and 50% among the undergraduates) than the Brazilians (32%) who based their answer more on personal opinion about the data.

In the following section I develop a general discussion of the findings from the questionnaires.

6.6 Discussion of the participants' questionnaire responses

The software based coding allowed the production of a larger number of codes which categorised the data gathered by the questionnaires. The classification of the responses related to individual details and reading backgrounds items gave a general picture of the different groups of participants: British undergraduates and postgraduates, and Brazilian undergraduates.

An analysis of the responses suggests that print media publications were frequently read by a substantial number of participants. However, a considerable percentage of participants did not mention print media as a frequent type of reading. In addition, the majority of participants indicated as most favourite reading a type of literature which usually does not include graphs.

In some way the analysis of responses of reading background items indicated unexpected information about the participants' reading. For example, these findings do not coincide with the discussion which several authors develop about the interpretation of media graphs as a frequent activity. Therefore, the findings from these questionnaires items bring elements to the discussion related to a crucial motivation to the use of media graphs in *school contexts*: the frequency of access to them in *reading contexts* (see discussion of contexts of interpretation of graphs in section 2.8 of chapter 2).

On the other hand, it must be recognised that there are other situations in which the participants might have access to media graphs which were not covered by the questionnaire items such as television programmes and adverts. In addition, it is reasonable to consider the characterisation of interpretation of media graphs as an

activity which is not only related to the frequency of access to types of readings. For example, if the macro-dimension of the interpretation of media graphs as a social activity is considered (e.g. Vygotsky, 1978) it is possible to conceptualise the use of graphs from a wider perspective.

In this study the questionnaire can be considered as a particular kind of *school context* of interpretation of media graph. To compose the questionnaire tasks the graph was extracted from the original source as occurs with the use of media graphs in *school contexts*. The questionnaire particularly emphasised written responses related to the interpretation of media graphs. As in other *school contexts* of interpretation, when participants were responding the questionnaire items they had limits on time and the way in which to express their interpretation of the graph.

The questionnaires differ from *reading contexts* of interpretation in which the participants usually have access to graphs. For example, when they are reading a graph in a magazine they do not have specific items to respond to. Therefore, it was expected that the questionnaire tasks would provide certain *exhibition* of components of *critical sense* in the interpretation of media graphs among a large number of student teachers. However, I was aware that this dataset should complement and be discussed in relation to the interviews dataset which would present different evidence about the phenomenon investigated.

On the other hand, I also emphasise that the participants seemed to respond seriously to the questionnaire which contributed to the reliability of this data. For example I did not have the problems which other authors reported when collecting data among students who had a lack of motivation to respond the tasks (Leinhardt, 1990) or difficulties in expressing themselves clearly when completing a written survey (Watson and Chick, 2004).

The two initial questionnaire items focussed on the interpretation of the graph through the production of 'positive' and 'negative' statements which could summarise the main idea of the data displayed. The analyses of participants' statements suggest that the way in which the graph emphasises the contraception dataset (e.g. dataset

placed on the top of the graph with larger pictures) did not direct the focus of their statements. Therefore, even though the percentage of statements associated with the contraception dataset (36%) was generally higher than those associated only with fertility dataset (17%) there was also a large percentage of statements (48%) which were related to both datasets and other non-displayed aspects of the data (see Table 6.9).

The majority of statements were also explicitly connected with a consideration of the context of data. This suggests that the majority of statements were not purely descriptions of the graph but included participants' opinions and conjectures about the topics (see example on Figure 6.4).

The analyses of the participants' statements also indicated consideration of numerical and quantitative relationships (see Table 6.12). However, a small percentage of statements seemed to be sceptical of these numerical relationships such as the contradictory relationship between contraception percentage and fertility rate in Eastern Europe.

The third item related to the contraception-fertility graph which invited the participants to take a questioning approach to the data displayed. In responding to this third item, a large number of questions asked (45%) related to other information about the data displayed (see Table 6.13) and to social context of the data (see Table 6.15).

Most of the questions seemed to be related to the participants' sceptical view of statistical and mathematical aspects of the data collection and data representation (see Table 6.16).

The second media graph task was also composed of three items. The first item of the road accidents graph had identical formation of the third item for the contraception-fertility graph task. The participants were invited to pose questions for the person who produced the graph. The vast majority of participants' questions requested additional information (66%) which might clarify their interpretation (See Table 6.17). A large number of those questions seemed to be related to the participants' sceptical analysis of the targets displayed on the graph.

The second item asked the participants to combine the data from both Total and Children roads accidents. The analysis of their responses revealed that a small percentage of participants (8%) indicated some misconceptions about the graphical representation.

The third item asked how realistic the targets displayed on the road accidents graphs were. The fact that only 13% of the participants responded that the targets were realistic (see table 6.20) also indicates that most of participants viewed the data with a certain level of scepticism. The answers for this item suggest that the number of participants who based their responses only on their opinion (46%) or on explicitly considering any piece of data displayed on the graph (31%) were equally balanced.

As I expected the data gathered from the questionnaires did not allow me to identify clearly the affective dimension of the participants' interpretation of the media graphs. However, I believe that some elements of the participants' responses associated with their emphasis on the social contexts of the data might be related to a kind of affective perspective. For example, the occurrence of statements and questions which referred to women's situation (e.g. commenting about women's opportunities and questioning about the exclusion of unmarried women from the data displayed on the graph) when the participants were interpreting the contraception-fertility graph (see Tables 6.11 and 6.15).

The analysis of the participants' written questions seemed to give support to the evidence found by Gal (2002) concerning his *worry questions*. The production of questions when interpreting the media graphs seemed to provide a more analytical approach of the data displayed on the media graphs.

In summary, the interpretative approaches of media graphs related to the participants' sentences and questions seemed to be associated with two main elements of *critical sense*: mathematical knowledge, and reference to social contexts to which the data could be related. As I expected, the questionnaire data did not provide evidence about the processes of *mobilisation* and *balance* of such elements involved

in the interpretation of media graphs. I anticipated that the findings from the interview dataset of this study could provide data about these aspects.

6.7 Summary of chapter 6

- The questionnaires explored the interpretation of media graphs by primary school student teachers who would be involved in teaching graphing.
- The use of questionnaire allowed a large data collection from different groups of participants: British undergraduates and PGCE students, and Brazilian undergraduates.
- The questionnaire items were related to individual details, reading background and media graph tasks.
- A preliminary manual categorisation was followed by NVivo based coding.
- The analysis of the frequencies of the participants' responses did not reveal much difference between undergraduates and PGCE or British and Brazilian students.
- The data gathered suggested that substantial numbers of participants appreciated literature which does not generally display graphs.
- The analysis of the participants' responses seemed to be associated with a complex range of elements. The empirical data provided evidence of the use of mathematical knowledge and references to the social context of the data interpreted.
- From the analysis of the questionnaire data I could not infer much about the process involved in the *mobilisation* and *balance* of the elements of *critical sense* in interpretation of media graphs.

Chapter 7

Findings from the interviews[1]

7.1 Overview

The use of interviews in this study had two main rationales. Firstly, the interview could allow the collection of more comprehensive data about the participants' processes of interpretation. For example, unlike responding to the questionnaire, during the interviews participants could interpret more freely without the requirement of writing down their responses which could restrict their analysis of the data.

Secondly, the use of interviews also allowed *interplay* between the data from two different sources (see discussion in section 5.2 of chapter 5). Therefore, the data from the interviews gave different evidence of elements and processes related to *critical sense* in interpretation of the same media graphs from the questionnaires. In addition, the interviews served to investigate the process and the meanings which comprised the participants' questionnaire responses through the use of *recall* (Calderhead, 1981).

The following section 7.2 presents some aspects related to the interviewees. In sections 7.3 to 7.8 aspects of participants' interpretations are discussed. The sections follow the sequence of interview parts (see Table 5.12 in chapter 5): briefing; questions about the contraception-fertility graph and Total road accidents graph; *recall* of the responses of questionnaire; debriefing. Section 7.9 develops a general discussion of the findings from the interviews. Finally, section 7.10 summarises chapter 7.

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[1] Part of the discussion presented in this chapter was published in Monteiro, C., and Ainley, J. (2004). Exploring the complexity of the interpretation of media graphs. In O. McNamara and R. Barwell, *Research in mathematics education: Papers of the British Society for Research into Learning Mathematics*, vol. 6, BSRLM, London, 115-128.

7.2 The interviews

As described in chapter 5 a number of volunteers were contacted to participate in the interview stage of this study. In total 13 British participants were interviewed. The interviews with the PGCE students were developed during the Spring Term in March 2003, while the undergraduate students were interviewed during the Summer Term in May 2003. Table 7.1 (below) shows information related to the interviewees.

Table 7.1 – Participants interviewed

PGCE participants			**Undergraduates**		
Name	***Age***	***Degree***	***Name***	***Age***	***Specialism***
Frank	21	Politics - Social policy	Alex	19	Science
Val	30	Urban studies	Max	19	Mathematics
Hillary	35	Music	Teresa	20	Mathematics
Joy	37	Geography	Sandra[2]	19	Science
Diana	40	Psychology	Julia	19	English
Betty	41	English	Liz	20	English
			Emma	41	English

Most of the PGCE interviewees were mature students who had a degree in humanities or social sciences. On the other hand, most of the undergraduates were 19-20 years old and were taking different specialisms. The fact that the interviewees were volunteers does not allow this to be a representative sample from the whole groups of British participants who responded to the questionnaires.

The analyses of the interviews were developed considering both the full transcripts and video which made available other aspects of the participants' speech such as body language and intonation. A number of possibilities for the type of analysis from the interviews were taken into account. For example, the development of case studies which focus on particular interviews was considered. However, I

[2] Although Sandra was interviewed she did not complete the questionnaire because she was ill at the time of the questionnaire data collection session. The analysis of her interview did not reveal much difference from the interview with the other participants who completed the questionnaires.

anticipated that an approach which would use all 13 interviews could provide a broader range of meaningful examples to discuss the phenomenon of *critical sense* in interpretation of media graphs

I saw these findings from the interviews as emerging from an interaction of factors involved in students' participation which needed to be taken into account. For example, the fact that the students volunteered for interviews during different term times, that they established different rapports with the interviewer, and that they had different feelings and expectations related to the interview situations, are aspects which may be relevant to understanding their responses and engagement in the interpretative situation.

The following section 7.3 discusses aspects of the first part of the interview.

7.3 Briefing: Starting the interviews

The briefing (Kvale, 1996) preceded the interview questions in which I conducted a conversation which helped the establishment of rapport. This part of the interview was also important in order to obtain the informed consent from the participants.

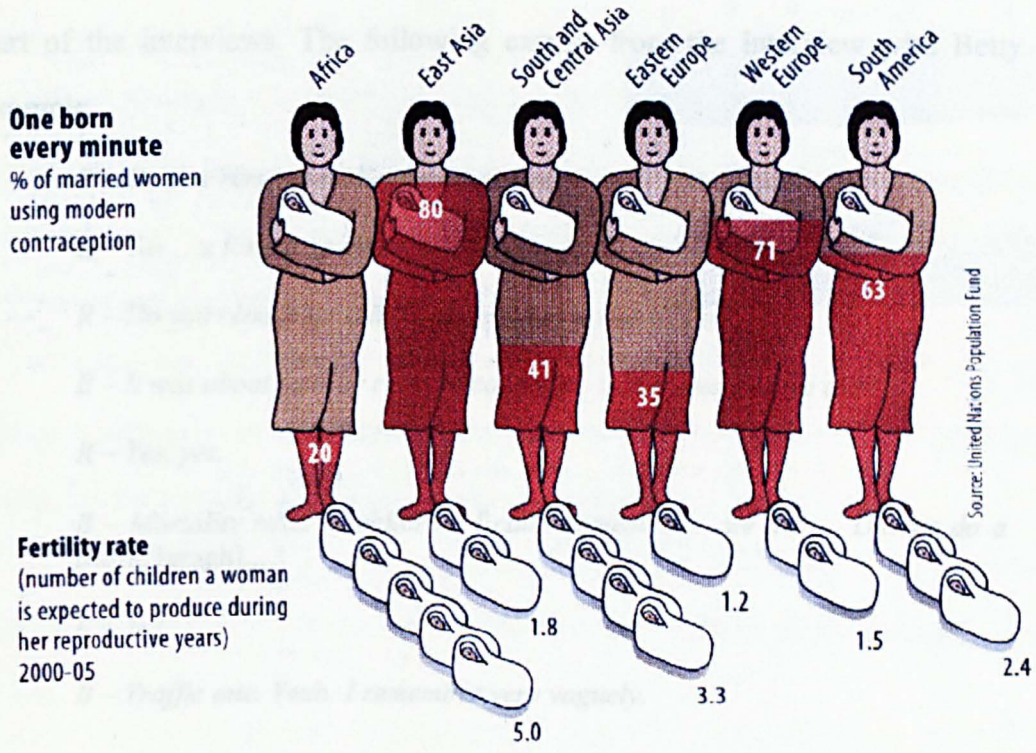
The first question asked whether the participant remembered completing the questionnaire. The rationale of this question was to identify which elements the participants could mobilise from their previous interpretation of the same media graphs which would also comprise the interview.

Some participants initially said that they vaguely remembered the tasks. For example, Frank, a PGCE participant responded.

F – It was about a graph, that's only what I can remember to be honest.

Most of the participants who remembered any aspect of the questionnaire tasks mentioned elements of the contraception-fertility graph (see Figure 7.1 below). I considered that this could be associated with the fact that this graph was comprised of images which were more memorable for the participants.

Figure 7.1: Graph reprinted from The World in 2002, The Economist, 2001, p.132



Other personal reasons could also contribute to make this graph meaningful for the participants. A particular example of this relationship with the theme is given by an extract from the interview with Val who was in period of pregnancy during both questionnaire and interview sessions.

R – Do you remember about the questionnaire?

V – Yes, we viewed a few graphs, weren't we? ...

R - Yes. But how about the graphs? Do you remember?

V – We're looking at why certain women... in certain countries... Was it to do with gender, wasn't it? And than... hum... I can't remember the... Women have children, the average of children per woman is different in different countries and we try to think of the reasons why...that was the bit [that] I remember, because I am expecting too... so [laughs] *[Rubbing her stomach]*

R – In that time you already were pregnant?

V – Yeah. [I have] *only got six weeks left. So, I do remember.*

In fact only two participants explicitly mentioned the road accidents graph task at this part of the interviews. The following extract from the interview with Betty is an example.

R – Do you remember the questionnaire?

B – Yes... a long time ago.

R – Do you remember a little about what it was about?

B – It was about fertility rates in countries, is that one that we did?

R – Yes, yes.

B – Mortality rates of children. I can't remember... we did ... Did we do a traffic [graph]*...?*

R – Yes.

B – Traffic one. Yeah. I remember very vaguely.

It can be observed that she mentioned an aspect which did not comprise the graph: *"mortality rates of children"*. The mention of the term "traffic" is also a vague association with *"road accidents"* which was the main topic of the second questionnaire task.

7.4 Questions about the contraception-fertility graph

In this part of the interviews I asked a range of questions related to the three levels of questions discussed in several studies which investigated the interpretation of graphs (e.g. Friel, Curcio, and Bright, 2001): "reading the data", "reading between the data", and "reading beyond the data" questions (see discussion in chapter 3). According to these studies, each type of question motivates a different process of interpretation of data. The "reading beyond the data" questions particularly request that the interpreter make relationships with data which is not displayed on the graph.

I considered that this typology would help me to investigate processes related to the *mobilisation* and *balance* of several elements involved in interpretation of media

graphs: processes which are related to the notion of *critical sense* in interpretation of media graphs.

As discussed in previous chapters, in this study this typology was used differently from previous research (e.g. Curcio, 1987). Therefore the questions were asked as part of an interview and used media graphs rather than multiple-choice surveys or written tasks with traditional statistical graphs.

During the interviews the questions were formulated orally and I also showed the questions printed in a piece of paper. This procedure allowed the participant to check the formulation in order to answer the question.

Each one of the following sub-sections 7.4.1, 7.4.2 and 7.4.3 describe the participant's answers for each type of question asked about the contraception-fertility graph.

7.4.1 Reading the data questions (contraception-fertility)

The two "reading the data questions" asked were;

> *What is the percentage of married women using modern contraception in South America?*
>
> *What is the fertility rate in South America?*

All participants responded to those two questions straightaway. Some of the participants were intrigued to know whether it was a trick question because it seemed too easy for them. The following extract from the interview with Julia exemplifies this:

> *J - Do you have the questionnaire?*
>
> *R – Yes, I do.*
>
> *J – Oh, right. I think I wrote some strange answers.*
>
> *R – No, I don't think so.*
>
> *J – It seems interesting.*

R – So, I would like to ask some questions about this graph. For example, what's the percentage of married women using modern contraception in South America?

J – South America? [Observing] *63%? It is a trick question, isn't it? Married women...* [Rereading the question] *Yeah.*

Julia's comment could be also related to expectations about the tasks at the beginning of the interview when the participants were not entirely sure about what kind of questions they would answer.

7.4.2 Reading between the data questions (contraception-fertility)

In order to answer the "reading between the data" questions the participants should relate more than one piece of data displayed on the graph. The first "reading between the data" question requires a comparison of the figures from fertility rates for each geographical region considering the percentages of contraception use displayed on the top dataset.

Which region has the lowest fertility rate using modern contraception?

The vast majority of the participants responded that Eastern Europe was the region with lowest fertility rate.

Some of the participants (Frank, Diana, Betty, Teresa, and Julia) hesitated to respond this to question because they observed that Eastern Europe did not have a percentage of contraception which could justify its fertility rate. These participants mentioned that East Asia could also be the answer even though they preferred to respond Eastern Europe. The follow extract from the interview with Teresa is an example of this interpretative approach.

R – "Which region has the lowest fertility rate using modern contraception?"

T – Well... East Europe... But then they use less contraception... is that? ... So all of these are using contraception in some degree?

R – Yeah.

T – So yes it is Eastern Europe...Because there is just one baby [picture]... *and it is only 1.2* [fertility rate].

Teresa seemed to ask for a confirmation from the researcher about her reading. She was unsure whether the apparent relationship between contraception and fertility should be considered in order to answer that question.

Frank also made a similar comment when he was responding to this question:

> *R – How about "Which region has the lowest fertility rate using modern contraception?*
>
> *F – The lowest fertility rate is in East Asia. Oh, there is other, Eastern Europe either. But that's difficult to say because whether they... whether they use much more modern contraception in Eastern Europe than in East Asia. So I don't really understand... Do you mean? Both are using modern contraception extended. So it's possible I think to say Eastern Europe has the lowest fertility rate. Well, presumably it is not because of modern contraception; because it's quite low percentage of the use of modern contraception. Presumably it is another reason ...of you look at if... If the question was: "which area has a...the fertility rate has been affected by this modern contraception?" It's probably East Asia, because that's where is used... the modern contraception is used most.*

Frank also seemed to be confused about his answer but he also followed the general idea of the question. He suggested another answer if the question was more specific.

Emma was also one of those participants who considered both East Asia and Eastern Europe as answers. However, she was the only one who answered East Asia, as can be seen in the following extract from her interview.

> *R – Ok. "Which region has the lowest fertility rate using modern contraception?"*
>
> *E – East Asia. Because 80% using contraception and 1.8 children. I don't know...* [Rethinking for a while] *Yeah I think is East Asia maybe Eastern Europe. Does that mean modern contraception use? Isn't it?* [Pointing to the contraception set] *Yeah.*

Although there is an indication that Emma considered a relationship between the contraception percentages and fertility rates in East Asia and Eastern Europe, when she was glancing at the graph she did not analyse in detail both possible responses (contrasting with Teresa's approach, see interview extract on page 151).

Emma also did not ask alternative questions to contrast the possible answers (like Frank did, see previous interview extract). Emma was interviewed during her only available time, the lunch break. Therefore, she was a bit rushed during her

interview. This contextual factor could have influenced the way in which Emma interpreted the data. On the other hand, this aspect of her interview could be like the interpretations developed in *reading contexts*.

The second "reading between the data" question asked participants:

> *Which regions have a higher percentage of married women using modern contraception than South America?*

The vast majority of the participants answered Western Europe (71%) and East Asia (80%). The following extract from the interview with Diana exemplifies this approach.

> *D – ... "higher percentage of married women using modern contraception than South America"...* [Re-reading quietly the question]*...South America is 63%... So, Western Europe... and East Asia.*
>
> *R - Why do you say this?*
>
> *D - Say South America is 63%...Here* [pointing to the bar]*... and then you've got Western Europe that actually is 71% and East Asia they use 80% Yeah.* [Answering and checking carefully the figures and the question as well].

It can be observed that she mentioned the regions in a specific order Western Europe at first and East Asia second, although Asia has the highest percentage (80%). She seemed to look first at the percentage of South America (63%) and then for the next high figure which was Western Europe (71%). The majority of participants responded to this question in the same way.

My analysis of the data related to the participants' interpretations when they were responding to the "reading between the data" questions confirmed conclusions from previous studies. Therefore, this type of questions provided an opportunity for participants to analyse the data globally rather than focusing on specific pieces of data of the graph.

Generally the participants tended to answer the questions only based on the data displayed. At least for this contraception-fertility graph task, this type of question did not seem to help the participants to *mobilise* other types of knowledge in order to

interpret the graph. Therefore, the analysis of the data from these participants' responses did not allow much exploration of *critical sense* in media graphs.

7.4.3 Reading beyond the data questions (contraception-fertility)

This type of question asked for predictions associated with the data. Therefore, unlike the previous questions, the "reading beyond the data" questions required information not displayed on the graph. In order to answer this type of question, I expected that participants would *mobilise* other previous knowledge and experiences related to the data displayed.

For the contraception-fertility graph the first "read beyond the data" question asked was:

> *What is your prediction for the fertility rates of South America between 2006 and 2010?*

It seemed that the introduction of this question destabilised the pattern of interpretation suggested by the previous types of questions. The fact that the "read beyond the data" question did not have an exact answer which could be identified from the data displayed seemed to motivate certain reactions from the participants. For example, four participants (Hillary, Joy, Betty and Emma) did not give any particular rate as an answer to this question. The following extract from the interview with Hillary illustrates this type of approach.

> *H – Right... South America...* [Looking at the graph for 8 seconds] *Well, I am just thinking if there is anything that might influence the range* [of] *the next four years... ... it is really hard to say* [looking at the interviewer]. *It is hard to say whether that will go down or up. In South America...I can't think what might affect fertility rate.*
>
> *R – Why do you think it is hard to say this?*
>
> *H – I think is hard to say because I am trying to think of them... You know, I suppose you need to think as a country... Whether they want to... Whether they are quite happy with that fertility rate or whether they feel to address the issue. And then, as a country that they might feel that it is quite acceptable, and in which case... It could probably be... just stay the same.*

Hillary realised that was difficult to give a figure without a deeper analysis using data (such as national social policies of the countries) not presented in the graph. In addition, she also considered aspects related to reliability of the data displayed on the graph, observed in the following extract

> *R – So, do you think... based in that information that you have you cannot predict the...*
>
> *H – Hum... I think just that... Obviously, there are other issues that could influence it. But ...* [Reading quietly] *I suppose really I would want to know how they got this evidence together... in the first place... What is the information they used it to get this evidence. Does it include every female person? Does this figure include every female person living in South America? Has it missed anybody else on that occasion? You know, I think... I probably want to know that. In which case why did those people slip through the net? And...So, I think it is hard to answer that. Is that ok?* [Looking at the researcher as concluding her response to that question and asking to move on]

Hillary's concerns seem reasonable because this question asked for a prediction which was based on other predictions (expected fertility rates). Hillary also emphasised that she was not comfortable with answering any further questions about that prediction: "*So. I think it is hard to answer that. Is that ok?*"

In the interview with Betty, I insisted and asked her for a specific figure, as can be observed on the following extract:

> *R – "What is your prediction for the fertility rates of South America between 2006 and 2010?"*
>
> *B – Hum... I don't know because it hasn't got. I don't know. ...I don't know. This is from 2000 to 2005. I don't know whether or not this is likely to be true. I don't know what other factors influence it. So I don't know whether or not stays the same or rise. I don't know if more South American women are using contraception or less so... If the education is improving or... I don't know! I don't know!*
>
> *R – Do you think there are many factors are involved in this prediction?*
>
> *B – Yeah.*
>
> *R – But if you base on just this data what would you say, just a guess?*
>
> *B – Hum...* [Analysing the graph for 15 seconds] *Well I have to say it would stay about the same... But I don't... I don't know it is just a guess.*
>
> *R – Do you think it should be the same for the next five years?*

B - I would guess that it would be? But I wouldn't, no... because I don't know... I don't know what's affecting the fertility rate. And then in the next five years I don't know if more women are using contraception than the fertility rate will may be... But if the fertility rate isn't based on the number of children being born, it is a theoretical rate then I would say the same. But... but I don't have enough information to be able to make a decision. I think. No, I don't! I don't know how to get the numbers!!!

Betty did not give any number as an answer. She said that the rate "would stay about the same", but she was uncomfortable about giving that answer. An indication of this was the repetition of the sentence *I don't know* 14 times in this extract of her interview.

However, most participants guessed an answer as the following extract from the interview with Sandra illustrates:

S – Well...South America? It's hard to say because I don't know... I don't know how much has been increasing or decreasing... I can't really say.

R – So it's difficult to say because you don't know...

S – Because it tells you... Only tell us you... The fertility rate in sort of one period of time, it doesn't say how it has been changing. So I can only guess.

R – If you would guess it is something about?

S – A guess? Oh, I really don't know. Hum... 2.3... [Smiling] *But that it's just a real guess.*

R – Because there's not enough information to do this prediction?

S – No. I just thought, well... I don't know... I would think that they'll be increasing...you know... contraception people using... Hum... But it might not affect it. No, I don't really no, and 2.3 is a guess.

Despite her reluctance to answer this question she guessed a figure in the end. Other participants also gave a number when I asked (Frank = 1.8; Val = 2.0; Teresa = 1.7; Julia = 1.5; Liz = 2.6).

Another three participants (Alex, Max, Liz) answered this "reading beyond the data" question guessing more than one figure. The following extract from the interview with Max illustrates this approach.

M – [Analysing for 10 seconds]. *Probably stay the same. I would say... You know. I don't know much about South America. So...* [Laughs] *Hum...*

Because it's obviously from 2000 to 2005, but the future years I don't expect to change that much so still about 2.4, maybe a bit less, maybe about two.

Max also recognises that he might be able to answer better if he knows about the South America social context.

From the analysis of the participants' responses to this first "reading beyond the data" question I could identify the emergence of other elements in their interpretations. The participants did not respond to the questions with an exact answer or rational explanation as they did when answering the "reading the data" and "reading between the data" questions.

The participants faced a question which might not have response or more than one answer. Therefore, I consider that the impact of the "reading beyond the data" question might have contributed to responses which express certain emotional components. For example, when Hillary and Betty were refusing to answer; when Sandra was justifying her "guess", and when Max was making joke about his lack of knowledge to answer the question (see previous extracts of this section), they were expressing themselves rather than only reasoning mathematically or statistically.

They also seemed to make relationships between the social context in which the data could be related as well as the methodological procedures to gather the data (e.g. see extract from Hillary's interview on pages 150-151).

The second "reading beyond the data" question asked for a specific fertility rate considering a hypothetical figure of 70% contraception for the country Argentina.

If the percentage of married women using modern contraception in Argentina is 70%, what would you expect fertility rate to be?

All participants answered this question based on trends displayed on the graph. For example, the extract from the interview with Alex is an example.

A – It's going to be between these two figures really 1.5 and 2.4 because Argentina is actually in South America and then they've got 63% of women using contraception which is 2.4; Western Europe is just above 70% is 71% is 1.5... So it's going to be between 1.5 and 2.4

Due to the lack of information to make a prediction, Alex seemed to consider similar figures for Western Europe (71% of contraception use and fertility rate 1.5) as well as South America (63% and 2.4). It can be observed that Alex did not comment much about the specific social contexts which could be involved in his prediction. However, a considerable number of participants considered both the trend and contextual aspects involved. The extract from Joy's interview illustrates this approach.

> *R – "If the percentage of married women using modern contraception in Argentina, for example, it is 70%, what would you expect fertility rate to be?*
>
> *Joy – (...)* [It is] *a higher use of contraception so you would assume there'll be a lower fertility rate, maybe down to 2. But then if you look at 70% that is very near to the Western European figure, and their fertility rate is lower 1.5, so maybe Argentina would be as well. And there are other factors acting there, I mean is Argentina a Catholic country? A lot of South America is catholic, isn't it?*
>
> *R – I think so.*
>
> *Joy – Is that still an influence? Because if it is... it might vary... it might be a higher fertility rate than Western Europe, because the influence... if there is one still of the Church promoting large families... So you would think that... if their rate is so close to that... if the fertility rate in Argentina is so close to Western Europe, perhaps they have more than Western European... than that maybe... Maybe their fertility is that low. But I would expect it to be lower than the average in South America.*

Joy made conjectures about the religious background of the population in South America. This contextualisation of the data seems to be a justification in that she could not base the trends displayed by the graph. In fact she was exhibiting her knowledge and experience related to the data. Joy has a degree in Geography and at the end of her interview she talked about her knowledge of South America and particularly about Argentina. Among other aspects, she mentioned that she knew an Argentinean family which lived in her town, and she knew about Welsh emigrants living in Argentina.

However, the lack of information available to make predictions was a frequent comment among several participants. An example is presented in the following extract from the interview with Julia.

> *R – So do you want to comment something about this question?*

J – Hum... You can't really... It is a funny little thing. You can't really tell from the pictures and stuff if there is of lots of factors affecting it. But like from the questions I suppose you look at what's on there and try to get...you know, from here [pointing to the graph]... *what's on there because... You haven't even got it there to see the connection.*

Julia was not comfortable with her interpretation due to the lack of elements on the graph which could support her prediction. In fact this lack of information was also related to her own knowledge about the data. This was indicated in a further part of the interview when I asked her to clarify her interpretative process:

R – Did you know that Argentina is in South America?

J – Oh, is it? [Laughs] *Oh... No, I didn't.*

R – Really? Ah, ok.

J – I'm not very good at Geography. Yeah, I do know. Come to think of it.

R – But again... do you think...?

J – Do you want to do that question again? [Referring to the "reading beyond the data" question asked previously].

R – No... I'm just checking did you answer basing on these... anyway in these bars? [Pointing to the contraception data set]

J – I didn't think it was in Western Europe... I didn't... I just thought...it wasn't on the graph... so because that was in the 70% in the question I said well that's 71%, so probably similar... 1.5 that's why I said that.

These extracts from the interview with Julia exemplify how complex it is to analyse which kinds of elements are involved in the process of interpreting the graph. Although Julia's comments explicitly indicated that she was considering the trends displayed on the graph she seemed sceptical of the presentation of the data (see extract on previous page). Therefore a combination of the absence of information and Julia's lack of knowledge about the data seemed to influence her interpretation. However, the components of other participants' interpretation approaches were not exhibited as explicitly as Julia's interpretation which made the investigation of elements and processes involved more complex.

Despite both "reading beyond the data" questions emphasising the relationship between contraception and fertility it seems that the participants considered this

relationship with reserve. The following extract from the interview with Sandra illustrates this.

> *R – If the percentage of married women using modern contraception in Argentina is 70%, what would you expect fertility rate to be in this country?*
>
> *S* – [Making a funny face like saying "it's very hard to say" and observing the graph and reading the question for 33 seconds]. *In Argentina?* [Observing the graph for more 12 seconds]. *I don't know... I would say 2.*
>
> *R – (...) why do you think?*
>
> *S – Well, that's really a guess as well, but... Hum... In Western Europe [pointing to the graph]... the percentage of using contraception is 71... Hum... And their fertility rate is 1.5, and then I thought: "well, it could be 1.5 in South America as well." Which a bit confusing because in Eastern Europe the percentage of using contraception is only 35... Hum... But the fertility rate is still very low... Hum... So I can't necessarily say it is because around the same in Western Europe is going to be the same number exactly. Hum... you know. Is that making sense?*

Using her mathematical knowledge Sandra emphasised the absence of apparent relationships between percentage of contraception use and fertility rate in Eastern Europe. This focus on the proportionality between the two datasets seemed to confuse her. However, from other interviewees' point of views this "non-proportional" relationship could be "explained" by other possible factors. The following extract from the interview with Diana is an example of this aspect of the participant's interpretations.

> *R – So in general do you think there is a direct relationship between...?*
>
> *D – In general, yeah. Yes, even though in Eastern Europe...* [Making funny face]...
>
> *R – ...there is a sort of contradiction.*
>
> *D – Well, yeah. Because life is never that simple really but there are other reasons that why they have... I mean I would say you can't tell from here, can you? Hum... This is actually saying they are... it's only to expect to produce, isn't it? In general they actually know... [Reflecting about] So I would say yes. The trend generally looks like you've got a higher percentage of women using contraception and you are going to get a lower fertility rate in general.* [Laughs] *They're all in general.* [Laughs] *You always have to have that exception, don't you?*

In order to explain the "contradiction" in Eastern Europe Diana contextualised the data recognising that from the graph she could not make many conclusions. She considered the complexity of both contraception and fertility as being human phenomena which could be related to a wider range of factors. The fact that Diana did not concentrate her interpretation on the quantitative aspects displayed on the graph (like Sandra did for example) may have assisted her, as she suggested with her "existential" statement: "life is not that simple".

Generally, I could identify that when the participants were responding to the second "reading beyond the data" question they tried to justify their answers based on a contextualisation of the data. This demanded the *mobilisation* of previous knowledge and experiences about the topic interpreted. Despite recognition of the importance of contextualising the data some participants could not develop extensively this interpretative approach because they did not know much about aspects of the data (e.g. geographical knowledge).

From my analysis of the participants' responses discussed so far in this chapter I could identify elements related to the notion *critical sense* in interpretation of media graphs. The categorisation of these elements was difficult because they seemed to be amalgamated. Therefore, I believe that any categorisation would not involve the whole complexity of a particular element and its relationship with others. Although I considered the limitation in specifying the components related to the idea of *critical sense* I developed a categorisation which comprises four elements:

1. *Mathematical knowledge*: the participants interpreted the quantitative relationships displayed in the contraception-fertility graph based on their mathematical knowledge. For example, Sandra analysed the mathematical relationship between the figures displayed on the contraception-fertility graph (see extract on page156).

2. *Contextual reference*: the participants made connections between the data displayed on the graph and their previous knowledge about the process of data collection, data analysis and social context which might be related to the data. For example, Hillary recognised the importance of data such as national social policies of countries (see extract on page 151).

3. *Affective exhibition*: the participants exhibited affective reactions facing a situation in which they could not develop a complete interpretation of the graph. The term *exhibition* is similarly used by Evans (2000) who emphasised that the affective components can only be inferred from the participant's reactions during interpretation of graphs. For example, Diana made an existential observation during her response to the reading beyond the data (see extract on page 156)

4. *Personal exemplification*: in order to interpret the graph the participant exemplified and justified his/her interpretation in making an explicit connection with previous personal experiences. For example, Joy interpreted the graph utilising examples which related to her personal experience (see extracts on pages 154-155).

The above four categories helped me to analyse aspects related to the elements of *critical sense* in interpretation of media graphs. However, I recognise that the boundaries between these categories are fuzzy. For example, when the *personal exemplifications* made by participants can be sometimes considered as *contextual references*. However, with this third category I wanted to emphasise the personal characteristics related to an example given by a participant to explain and justify her/his interpretation.

Generally, the aspects of participants' interviews discussed in this section complemented and extended the evidence gathered from the questionnaires about elements which comprise *critical sense* in interpretation of media graphs. In addition, the interviews also provided evidence about the processes which involved this notion of *critical sense*. I could particularly identify for example that the impact of the "reading beyond the data" questions motivated a different process which *mobilised* different elements.

As discussed on chapter 5, during the interviews I made an explicit link between two research situations when I developed the *recall* of the participants' questionnaire responses during the interviews. Aspects of the *recall* of the contraception-fertility questionnaire task are discussed in the following section.

7.5 *Recall* of the questionnaire responses to the contraception-fertility graph task

The presentation of the participants' questionnaire responses during the interview was a methodological procedure based on the conception of *stimulated recall* (Calderhead, 1981). The rationale of the *recall* was to give an opportunity to the participants to reanalyse their responses and reconstitute their interpretative processes when responding to the questionnaire. The following extract from the interview with Hillary is an example:

> *R – So, at that time you... do you remember your questionnaire?* [Showing the answers that she produced when completed the questionnaire].
>
> *H – Oh, yes. I have changed my answer complete, haven't I?*
>
> *R – I don't know. So, do you want to have a look?*
>
> *H – Oh, god. Interesting! Hum... Right...* [Reading her own answers] *Right.... Right yes... yeah.... Right ... yeah I can see...*
>
> *R – Do you want to comment your answers?*
>
> *H – Yeah. I would like to comment* [...] *to be honest when I came here I had forgotten a lot of what we discussed and the main points. So, I don't know... perhaps I was looking at it from different a perspective and certain isolation of that* [pointing to the graph]...

It can be observed that initially Hillary evaluated her questionnaire answers as another perspective of interpretation which emphasised only the graph itself. In contrast, her current interpretation during the interview seemed to relate other aspects which were not displayed on the graph.

This *recall* could also encourage the participants to compare their interpretations of the same graphs in two different research contexts. In addition, the *recalls* could motivate a continuation of the participants' current interpretation related to the interview questions. The following extract from the interview with Val is an example of this approach.

> *R – Do you want to comment on your answers?*

V – [After observe the graph for 10 seconds, she started her interpretation pointing to the questionnaire written answers] *Still stand by the percentage of women in East Asia using contraception is the highest in the sample... hum... that one... I don't know why I said that, but I would suggest might be something to be with strict child police in China and... you know... the implications.*

R – Do you thing it is a positive thing... this level of contraception?

V – I think it is a positive message if the women have a choice, I think that's an important... but... "% of women in East Asia using contraception is highest in the sample" [re-reading her positive message] *I think I interpreted that just as one thing that you could actually truthfully say about the graph as a positive message* [observing the graph for 20 seconds].

R – Now, you would say the same... the same thing, the same opinion, the same affirmation?

V – I might switch around...

Even though Val realised that term "choice" could be positive or negative, she used as a negative. It can be observed that she brought different elements which are related to her background to her interpretation.

This issue about the choice to use contraception was also mentioned by at least two other interviewees when they were reanalysing their questionnaires responses. Therefore, the *recall* also served to clarify the different meanings which each participant had when they were responding to the questionnaire. For example, Betty utilised the term "choice" differently from Val (see following extract below).

B – So I thought possibly there wasn't a relationship, but I mean have been said married women using modern contraception could be still choosing because they're using contraception doesn't mean they are not having children. It can mean they're choosing to have more children because the figures here they're very different, 80% of women in Eastern Asia are using contraception and the fertility rate is 1.8, and in Western Europe is 71% to 1.5... So those figures are quite closely related but in Eastern Europe they have... their fertility rate is lower than anywhere, but only 35% of them are using contraception, so there are... must be other reasons why their fertility rate is so low, which is presumably health and economical situation. How miserable it is Eastern Europe presumably. But we all talked about this for quite a long time. We did find very confusing. And we do need lots more information to be able to understand what these figures are telling us.

Betty emphasised that the choice to have babies cannot necessarily be excluded by the use of contraception. Betty's observation was related to her analysis of the figures for

Eastern Europe which was contradictory. Therefore, she started to *contextualise the data* analysing the possible reasons for the figures (e.g. women choices; health and economical situation).

These different meanings associated with the same word used in statements produced by the participants could not be identified from the analysis of the questionnaires. Therefore, the *recall* was also important in identifying what a particular participant's answer meant when they answered the questionnaire. For example, in the following extract Julia was reanalysing a question she produced:

> *R – (...) you asked this question "why did you use pictures of babies rather than a clear graph which shows the points?"*
>
> *J – Ah yeah. It's rounding off to the nearest baby, isn't it? So it's like 1.2 is just one baby; 1.5 is only like 0.3 more and then they show 2 babies... so looks like so much more 0.5 ... that's not very accurate... it's a bit deceiving... Eastern Europe doesn't seem to make sense on the whole... I don't know much about children... I don't know Eastern Europe...* [Commenting very quietly and being sarcastic]. *I just didn't see where that fitted, or why that was... ...There you go. I don't like this graph.*
>
> *R – You don't like it?*
>
> *J – I don't like it.*
>
> *J – It's confusing me. It's a bit manipulative; such like the babies and...hum... I would like to know more about where they got all these things from as well... these figures from.*

In this extract Julia explicitly specifies which aspect of the pictorial representation of the data motivated her question.

Finally, the *recalls* were also an opportunity for the participant to be explicit about why they had or had not answered items of the questionnaire. The following extract from the interview with Frank is an example

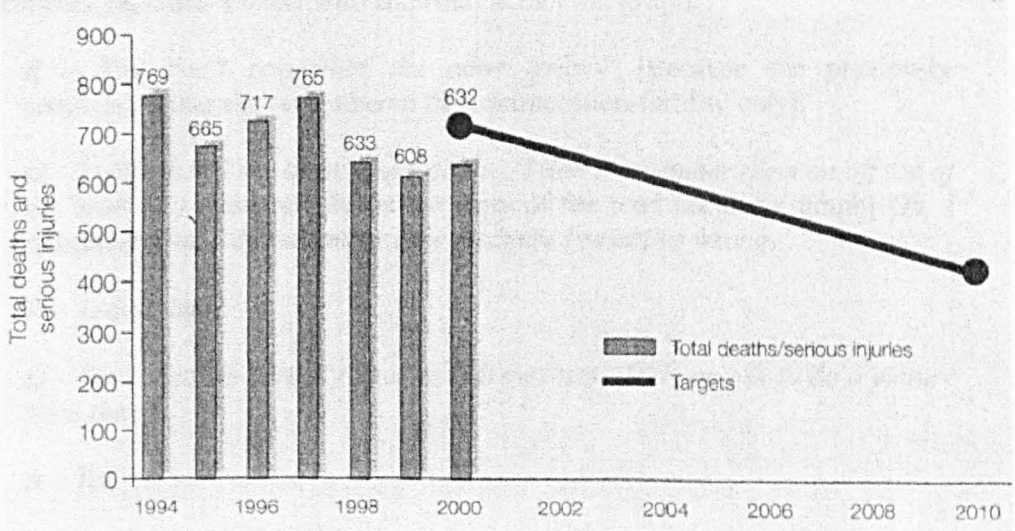
> *F – I remember answering these questions and it is about positive and negative messages and I found quite difficult to answer ... I see a graph like this as being a kind of neutral without a kind of message which is a positive or negative. I see maybe as a factual rather than judgmental so I found quite difficult that why I left that one blank. And one thing that I referred to a negative message is really the assumption that is not definitely drawn from that... I kind of... perhaps... hum... the availability of the contraception varies across the world. I mean, perhaps... I cannot see truly from that... it's just something that I guess. So...*

In this extract Frank explains why he did not answer that item of the questionnaire and he also expressed his perspective on the "interpretation of graphs". However, even though he recognised this perspective, the analysis of his interpretation indicated that he also gave his opinions and hypothesised about the data. Frank was sceptical about the data displayed (e.g. the unreliable relationship between contraception and fertility)

7.6 Questions about the road accidents graphs

This section discusses the participants' responses for the total road accidents graph (see Figure 7.2 below). This part of the interview also comprised 6 questions related to the three types of questions used in the first media graph task. These questions were asked when the participants seemed to be more engaged in the situation. The fact that they had already responded to the questions related to the first task could have contributed to the situation in which they knew what kind of questions to answer and were not anxious about it.

Figure 7.2: graph reprinted from *Quality of life in Warwickshire*, 2001, pp. 93-94.



In addition, the fact that the participants reanalysed their questionnaire's responses could have also contributed to the development of an interpretative situation in which they knew the purpose of the interview. For example, some participants started to state their impressions about the road accidents graphs before I asked any questions. The following extract from the interview with Liz is an example.

L – I remember that [the road accidents graph] *I was thinking that is stupid, because like you comparing the graphs* [but] *they are not on the same scale... so if someone is just like looking at newspaper not really reading into the graphs were and then just think: "oh, they are both the same". But they're not because this is sort of seventy and that is up to nine hundred. So they should be on the same scale. And that it should be on the same scale as well* [the target lines]. *(...) Yeah I remember thinking about the scale. Yeah... and the target would be... a lot precise. Who decided that would be the target. It looks like they just drew line just to show that would decrease they did not properly predict it but...then how many years? In ten years they expected to go from 632 to about...* [Looking at closely]... *450 or 500 which is quite a lot over ten years. So the number of cars is increasing some how they expected the number of deaths to be decreasing if the cars are increasing. So...*

Liz's comments were sceptical about the technical aspects of the graphical representation [*"they should be on the same scale"*] and the context in which the graph could be read [*"if someone is just like looking at newspaper"*]. She also compared the data displayed as a prediction [*"They did not properly predict"*] with the actual situation [*"the cars are increasing"*].

Another example of spontaneous comments comes from the interview with Diana who immediately remembered her mistake when she responded to this questionnaire task associated with the road accidents graph.

R – You don't remember the other graph? [Because she previously commented that she remembered the contraception-fertility only].

D – I will when I see them. But I don't... I don't remember them on off top of my head (...) [research shows the copy of the road accidents graph] *Oh, I remember that. I do remember now, because I read this wrong...*

R – At that time?

D – Yes... Did we actually have to redraw them? Did you ask to do a picture from them?

R – Yes.

D – And I... instead of ... because this is the total road accidents which presumably included children but I was actually reading it as adult, I can remember that! I read that "adult casualties" and "children casualties"... and then I added two together when in fact they were... they were actually the total, weren't they? Inclusive this figures they are actually included in those [pointing to the bottom graph was include in the top graph]. Yes. So I do remember now. [Laughs] *How long was it?*

The fact that Betty remembered that she misread this graph is a indication that during the process of her interview she was mobilising her previous interpretation of the graph as well as extending her analysis of that particular graph.

It seems that considering the participant's engagement at this stage of the interview is important in analysing their responses to the three different types of questions which are discussed in following subsections.

7.6.1 Reading the data questions (road accidents)

For the second interview task the following "reading the data" questions were asked:

What is the total of number of deaths and serious injury per year?

What is the lowest actual death and serious injury rate?

Almost all participants responded promptly to the first question. It seems that some of them did not want to say each figure although they knew the answer. This can be seen from the following extract from the interview with Emma:

R – "What is the total of number of deaths and serious injury per year?"

E – Per year? [Analysing carefully the graph and the question for 40 seconds]. *Right. Hum... For adults?*

R – Yeah

E – 94 769... 95 665, 96 715, 98 633, and so on... yeah.

The fact that she did not mention all years did not suggest that she had not observed the whole range of figures displayed on the graph. However, in the interview with Teresa, it could be observed that she misread the figures when answering this "reading the data question" as seen in the following extract.

R – *"What is the total of number of deaths and serious injuries per year?"*

T – Per year? Which year? What do you mean? Any year?

R – Any year.

T – Well... in 1994 is 769; is it right? In 1996 was 717; in 1998 was 633; in 199... 2000, 632.Sorry, should I say why... How would I... Well... This is total deaths and serious injuries... and you've got the plots against the year... So

this is a kind of half through the year.... These ones are each... kind of a year land mark...I think...

R – Those at the middle correspond to another year or...

T – These what? Sorry!

R – Because you said in 1994, in 1996 ...

T – Ah... 1995... Sorry. Yes. That means the year in between not the middle of the year. Yeah. Ok.

It can be observed that she spontaneously started to explain how she answered the question and with my intervention she realised that the figures represented even years as well as odd years.

The second "reading the data" question was promptly answered by all participants without comments.

7.6.2 Reading between the data questions (road accidents)

The first "reading between the data" question was also promptly answered by all interviewees.

Between 1994-1995, and 1997-1998, there was a decline in the number of deaths and serious injuries. Which period represents the greatest decline?

Analysing the explanations given by the participants there were two main strategies for answering this question. The most frequent strategy mentioned by the participants was mental subtraction of figures related to each period of decline, as exemplified by the following extract of Joy's interview.

Joy – [She was rereading the question written down on the sheet] *104 here* [Analysing 1994-95]...*This one in 1997 to 98. Because the drop was 132... and that's a drop of a 104. So it is this period here 1997 to 98.*

R – What did you? How did you know this?

Joy – This is a total figure, it's not a percentage figure. I just calculated the difference... the total difference... the decline in this period here was a 104 deaths and injuries [1994-95], *and the decline here one 132 deaths and injuries. So that's the higher one. This is the total figure.*

However, a few participants responded to this question by identifying the greater decline by visual comparison, as exemplified by this extract from the interview with Liz:

> *L – At those two...* [Analysing the graph] *It's the second. It will be 1997 to 1998. ...* [Checking again] *Yeah. The greatest decline.*
>
> *R – How do you know?*
>
> *L – Hum... you can see from... the graph the difference between the heights of the bars... so between these two and these two. Just look at the difference of heights... you could work out exactly what... Just by it... you can see that difference.*

The second "reading between the data" question was:

> *Which years represent the highest and lowest number of deaths and serious injuries?*

This question was promptly answered by all participants without comment.

As observed in my analyses of the participants' responses to contraception-fertility "reading between the data" questions, their interpretations of the graph tended to be restricted to aspects of the data displayed. Therefore, the participants did not seem to *mobilise* other kind of knowledge related to the data interpreted.

7.6.3 Reading beyond the data questions (road accidents)

Unlike the reactions of some participants when they were responding to the contraception-fertility questions, all responded to the first "reading beyond the data" question related to the road accidents graph.

> *What is your prediction for death rate and serious injury in 2001?*

It can be observed that this question referred to "death rate" whilst the figures are actual numbers of casualties. The participants did not make any comment about this aspect of the question which could indicate that they were unaware of the change of term used.

The vast majority of interviewees predicted that there would be a decrease in 2001. The following extract from the interview with Alex is an example of this approach.

> *A – It is going to be around I think... It will decline slowly from 632... I think it may be about just a little higher in 1999 say about 620 around that figure. If it keeps on dropping as it's at moment. It is going to slowly decline I think* [point to graph]. *Because generally the trend is slowly dropping.*

It can be observed that Alex seemed to base his interpretation only on the graph. He saw a declining trend in the graph and did not comment much about other aspects which could influence his interpretation. However, a reasonable number of participants answered this question with a *contextual reference*. For example in Teresa's interview, she was dealing with a question that did not have an "exact answer", she initially tried to observe any trends from the data displayed. Suddenly she realised that a possible trend could not be the only factor that could be used to predict the answer. Then, she conjectured about the possibilities of change in the data.

> *R – What's your prediction for death rate and serious injury in 2001?*
>
> *T – Hum... Well... From this it looked like it kind of ... went down and than went up, went down and then starting to go up... So it might got a little bit more... But then it depends on what's being changed. Maybe... Like whether they've done anything in particular to try and reduce road accidents so they just make a prediction... I don't know... Yes, say... say 665. I mean that will be ... that kind of match's the graph slightly... so we're going to go lots a little bit like this...*

After she gave the answer considering the social context of data interpreted, she "came back" to the graph to test whether her interpretation would be coherent with the presented trend. However, in the following part of the interview, she demonstrated her uncomfortable feelings about the representation of the target.

> *T – The target... I don't know. The targets don't really mean anything; I mean you can make a target go down to zero... So if it is about there...then that is about 665 if the targets right. I mean they gone up a bit from here, haven't they?* [Year 2000] *Perhaps, they will stay the same. (...) I don't know. I mean I wouldn't... It's difficult, because always you have to be a bit suspicious about where it came from...then you know perhaps all the speed limits have been changed now in 2000 and what ... certainly bought all the speed limits down, put road humps and things on all dangerous the roads and... So... Yeah.*

This particular extract seems to be an indication of the phenomenon of *transparency* (Ainley, 2000b) related to the interpretation of the data. Teresa was looking at the target but seeing the social context which she knew about. She emphasised a sceptical attitude in her comparison of the data displayed with other elements which were not presented by the graph.

Another example from the interview with Betty also illustrates the use of previous knowledge and experiences in the participant's interpretation. In the following extract from Betty's interview she was trying to identify any trends related to increases and decreases during the period between 1994 and 2000 to answer the question.

> *R – "What is your prediction for death rate and serious injury in 2001?"*
>
> *B – In 2001... Well I don't know. It's... there doesn't seem to be a trend. It gone from 765 to 633... it's dropped down again, but then its gone up to 632 [year 2000], and here I'm presuming that this was the rate it wasn't the set target. I'm presuming but either way even if you look at the graph, it has gone up...*

Betty was looking carefully at the figures presented. She realised that the figure of 2000 confuses the targets starting point which is differently displayed from the other total numbers of road accidents (see in Figure 7.2 that the number of casualties for 2000 was placed above). Therefore she initially emphasised a technical aspect related to the structure of the graph. However, she also introduced aspects of her *personal exemplification* related to interpretation of graphs when she realised that *mathematical knowledge* would not be enough to answer the question.

> *B - ...But throughout the whole period there hasn't been a set trend it dropped down* [1994-1995], *it's gone up* [1995-1996], *it's gone up* [1996-1997], *dropped down* [1997-1998], *dropped down* [1998-1999], *it's gone up* [1999-2000]. *If you based it on that... My husband is a currency trader; so all day is very boring he looks graphs all day. And he follows trends. That's how he buys and sells currency depending on trends. So he would look at this graph, he would say "Ah well the trend on it is to fluctuate" and he would draw lines in, and then he would say: "ok, dropped down, went up twice, and dropped down twice, it's gone up". Now he would plot a line to see, and he would go back over many years, he would look for the trend to see if it followed a certain pattern. It is actually quite interesting!. So he would want to look at more than this, he would probably say: "well maybe it would rise a little bit". But, again for me I don't have any information. I don't know what*

they're doing. Are they... you know... advertising more, trying to educate people, making people to wear seat belts, and things. It's hard to predict from these figures what's going to happen.

She brought into her interpretation a description of her husband's professional procedures. Her example could provide a meaningful discussion about the unconscious components of Betty's interpretation (e.g. as developed by Walkerdine, 1988, and Evans, 2000a). However, considering the purpose of this study this aspect could be viewed as *affective exhibition* which comprised Betty's interpretation.

The example given by Betty is also related to her *mathematical knowledge* associated with interpretation of graphs (e.g. analysis of trends). In addition, I also see Betty's exemplification as being connected with *contextual reference*.

When encouraged to specify a prediction, she recognized that it was difficult but made a prediction.

B – If I have to then, I would say it would rise slightly. Well if was 632 in 2000, maybe in 2001, if it rose there, maybe 640, something like that. But it's a guess. And I don't have enough information to be able to make a trending [moving with her hand like a curves of a graph, going up and down]... *a trending estimate of it.*

Therefore, it seems that her reasonable answer was based on the *balance* of *mathematical knowledge*, *personal exemplifications*, *affective exhibition*, and *contextual reference* involved in her interpretation of this media graph.

Another example in which I could identify a similar process of interpretation comes from the interview with Hillary. She developed an interpretation which expressed her feelings about the data displayed on the road accidents graph:

R – "What's your prediction for death rate and serious injury in 2001?"

H - 2001? Right. Hum... Yeah... I would say... eh... It would be... I mean I know it is going up... I know it is going up a little bit there. I think it would be down again about... says 600. At moment is going up at... Yeah... I think it will reduce it... I am not really going by... the graph, the flow of the graph... I am just going by a gut feeling more than anything. You'd like to think that it's coming down.

In this part of the interview, the student began by looking closely at the media graph, noticing the upward trend over the last two years, but then responded in terms of her

feelings about the issue of traffic accidents. Then I encouraged her to try to specify a prediction:

> *R - So do you think it would be some...If you guess some number, some rate?*
>
> *H - Yeah, again...I am not...it's very hard to say because...I'm thinking that it's...I am just thinking of...basically the media coverage on this type of thing...And...especially around Christmas time...there is always a focus to control the number of accidents on the road, and I think this country...Well, I know this is Warwickshire, but I think this...the government does do...does make an effort...and obviously there are reductions. So I am basing my information on that, not just what the graph is telling me. But obviously going from last...Going from year 2000. And...yeah...hum...600. I don't think there will a dramatic decline. But yeah...if I would say figure, say 600.*

When asked for a 'figure' she gave reasons for the limits of her answer, in terms of her knowledge about attempts to improve road safety. She tried to get a balance between her *mathematical knowledge* related to the data displayed, her 'feelings' and her knowledge about the social context to which the 'figure' might be related. At the end of her interpretation, she gave a reasonable conclusion based on the different aspects that were involved in her reading.

The second "reading beyond the data" question related to the road accidents graph was:

> *If the targets for 2000-2010 were met, what do you think the pattern might be for 2010-2020?*

As discussed in chapter 4, the surrounding text in which the graph was published mentions that Central Government in March 2000 expected a 40% reduction in the number of people killed or seriously injured in road accidents. However, neither the written text nor the graph mentions an intended figure (about 379 casualties) for the end of the target period (2010). This omission does not allow an accurate comparison between the actual figures (2000) and the planned results for 2010. The second "reading beyond the data" question actually asked about the figure after a 20 year-period which would hypothetically be a 40% decrease. Therefore the answer would be a figure around 227 casualties (deaths and serious injuries) by 2020.

Only two participants responded to this question by basing their interpretation on the trend displayed by the graph. This extract from the interview with Emma is an example of this approach.

> *E – It'd be probably a bit higher again, wouldn't it? This is just the fact... about a third about perhaps another third go down... on the actual. The target is 630 and look down there* [the end of the target line], *which is approximately 415. So it's about a third of... So probably it will be another third... So probably it'll go down to... hum... 250.*

It can be observed that Emma used an approximation strategy and gave an answer which was very close to the government target. However, she did not consider any other element related to the context of data.

On the other hand, most of the participants responded that the figures for 2010-2020 would be around 400 casualties because they made *contextual inferences* related to the data displayed. The following extract from the interview with Max is an example of this approach.

> *M – Well... I mean, by the graph you would say go down again, but realistically if I would say... it would...* [Slow voice and looking at the graph]... *you know... stay the same, because you can only go lower with stopping road accidents happening...* [They] *are going to happen... So...Thinking about the context of it... I would say it was going to stay the same... like more it is levelling off rather than carrying on going down...*
>
> *R – If I would ask some number. Can you guess?*
>
> *M –* [Analysing the graph] *Hum... I mean they've got about...what's that? 450... if carry on... I would assume that it's going to stay around there... for the next period... like 400, 500 that kind of area rather than carry down to 300... It's going to stay like 400 or 500 something like that. Between that period... it's a sort of levels off.*

Max's interpretation connects aspects from the data displayed with his knowledge and opinion about road accidents. A similar approach was developed by most of the participants.

An idea present among the interpretations of the participants when answering "reading beyond the data" questions was related to opinions that the figures for road accidents were levelling off (as can be observed on the previous extract with the

interview with Max). In the following extract from the interview with Liz this approach can also be observed.

> *R – "If the targets from 2000 to 2010 were met, what do you think the pattern might be between 2010 and 2020?"*
>
> *L – I don't think their targets were right anyway. But if they were then I don't think they would keep decreasing. I think it will level off on the graph. I think it probably stay around that one figures because there are so many cars on the roads. Then it'd be silly say just keep decreasing it's not going to happen. Even though promoting education of crossing roads and things like that... People don't drive secure, safe... And you know... Road car accidents could be anything from someone on the road or a crash or anything... nobody seems to restrict to speed limits in this country I'd say ... it's not going to stop a lot of deaths and there is everyday. So and I think if it did so from the highest it will probably level off.*

A similar kind of sceptical approach was observed in Teresa's interview. She made a distinction between what the graph represented, and what would be a "realistic" answer based on her own analysis of the data.

> *R – How about if the targets... from 2000 to 2010 were met. What do you think the pattern might be from 2010 for 2020?"*
>
> *T – If they were met! Wow! That will be good. From 2010 to 2020 I think it will probably level out... hum... because always is going to be some... It might be down a little bit more... But,* [She was measuring with fingers on the graph]. *It is not going be down the same steepness as because we will never get nobody dying unfortunately. So I think it will go down perhaps a little bit and level out. I think. Yeah.*
>
> *R – Do you guess a number?*
>
> *T – By 2020, perhaps... I don't know... Perhaps 300 even, maybe, yeah.*
>
> *R – Do you want to comment this...?*
>
> *T – Hum... I mean... Yeah... Deaths and serious injuries... there was a serious injury... and you can always class a serious injury as the same every time? Yeah... and... I suppose Warwickshire does that mean all of roads in Warwickshire? Are all the motorways included or... that kind of thing? The target I don't really... I mean... They... It looks like they are taking a line... near perhaps I don't know... But I don't think it sounds realistic... and than... Well, I suppose... Unless they... If they had a bit of writing to say what and how they going to make this happen. That it's not going to happen by magic, is it? So, yeah... (...) This is always interesting in one way... I know you can't really compare them. But they're put next to each other on a kind of "compare these" kind of way. But, you can't really compare them because its... I don't know whether the proportion is going down or not... Don't know.*

Teresa definitely did not believe in the trend represented on the graph, and analysed the structure of the graph criticising the implicit intention of showing the relationship between actual rates and targets displayed as a rectilinear decrease.

Another example of several aspects which composed the participant's process of interpretation comes from the interview with Hillary. In the following exchange, she seems to want to believe in the trend, but did not find a strong argument to base her answer on:

> *R - "If the target for 2000-2010"...there is a target there..."What do you think the pattern would be from 2010 for 2020?"*
>
> *H - 20...All right...hum...I think provided that technology doesn't take over people's well being...Then...I think the pattern should decline. But there are so many other things that might influence that pattern, like population rates...and...It is difficult to say...it is really difficult...it is hard question that...But I think...I think it would be a decline. I think there always be a decline, because it is such important issue...And then...There obviously... it always has been history of some kind of decline. But obviously things come along the way that interrupt the flow...obviously here* [pointing to 1997 figure on the graph] *there is...more deaths on the roads. There was obviously reason...Well, I don't know. It is hard to say whether its death and injuries. (...) But obviously that was addressed, because there was a big drop there* [1997-98]. *So, I think there is always a kind of picture of a decline, or an attempt for a decline. With something as serious you know...as this issue.*

Hillary moves between looking at the patterns shown on the media graph (*mathematical knowledge*), considering the context in which the road accident occurs (*contextual reference*), and expressing her desire to see safer roads with lower levels of accidents (*affective exhibition*). She seems to be reluctant to face up to the complexity of the question. However, when she was encouraged to specify a prediction, Hillary managed to "guess" an answer that seems to be based on the media graph, but also considers aspects such as the "hope" that was implicitly present in the interpretation:

> *R – If you could say a rate as well?*
>
> *H - Rate? Do you want me to say what I think that death and injury rates might be...? Right, so if it's starting at 500 which it's obviously that's what they're hoping...I don't think its actually going to hit the bottom. I think there is always going to be deaths and injuries on the road. I don't think you ever*

avoid that happening, but it might be...For instance, a target...a realistic target might stretch from 500 to...say 300...Yeah, it seems a realistic target.

R – Because you don't think it will be zero.

H - No, I don't think that will ever happen. No, I don't think that...I think there is always going to be accidents and deaths on the road. Yeah. I think that would be very hard to control...to [avoid completely]*...Completely, yeah. I think there will always be some statistics about this, because obviously there will be bad drivers.*

The indication of emotional components which contributed to Hillary's interpretation was emphasised when she verbalised an important aspect which had been omitted before: she had actually been involved in an accident (*personal exemplification*). The following exchange shows this specific part of the interview when the interviewer invited her to reanalyse the answers produced on the questionnaire some months before:

R – You produced these questions at that time.

H – All right, that is interesting.

R – Do you comment this?

H – [Laughs]

R - ...Just if you want to...

H - It's just interesting to see...That might...hum...I came up with similar things with this graph compare to other one. And that has more to do with the fact that I feel quite strongly about this...And then, I think I can perhaps relate to this more...you know, as a person.

R – Why do you?

H – I have been involved in an accident myself...

R – Hah...I'm sorry.

H - I think...But...Oh no...It wasn't a particularly serious accident. But...I can perhaps relate to the statistics more...I think. I can actually see what it's telling me.

This moment of the interview was an opportunity in which she compared both situations in which she had read the media graph. It was a moment in which she could make explicit a factor which might be meaningful for her interpretation. We can infer

that Hillary's motivations and wishes played a prominent role in her interpretation. The fact that she cared about road accidents and that she was actually involved in one herself, was an essential part of the meaning of the media graph for Hillary. She was trying to see what she wished to see, even though criticising and recognising the limits of her interpretation. Hillary's interpretation seems to be characterized by a 'conflict' between the different elements involved: *mathematical knowledge*, *contextual reference*, *affective exhibition, and personal exemplification* related to the data interpreted.

From my analyses of Hillary's interview I could infer that the *mobilisation* of these previous elements motivates an *emergence* of new and different meanings during the interpretation of the media graph. In addition to these processes of mobilisation and emergence, I could also infer a needed *balance* process in which Hillary could balance the influence of the elements in her interpretation in order to respond to the question.

These inferences from the interview with Hillary are an indication of the complexity of elements and processes related to the notion of *critical sense* in interpretation of media graphs.

7.7 *Recall* of the responses of questionnaires related to the road accidents graphs.

As happened with the *recall* of the questionnaire responses related to the contraception-fertility graph, the participants reanalysed their answers from the road accident graph task. The following extract from the interview with Joy is an example of this *recall*.

> *R – How about the question that you asked at that time?*
>
> *Joy – "What action was taken in 1997 which started a downward trend in road death (speed cameras)?"* [Reading quickly the question produced] *It might be speed cameras... because speed cameras were coming in about five years ago. It might be that. But why has it gone back up?* [She was analysing the increasing in 2000]. *There are a lot more cars on the road. Would cause more cars accidents? Hum... In those particular years they had very strong*

anti-drink-and-drive campaigns at Christmas? Or is it something to do to the number of police in the force? The police numbers that actually do road traffic duty have they dropped because you know... it does... They do stop people speeding. So if there aren't the police staffs to go and do that job then there probably will be more accidents statistics. I'd be quite anxious to know that as well (...) Perhaps I haven't enough information to make that assumption. We need to know why that happened because it might continue to go back up. Maybe that was a particularly good year [1997] *that isn't going to be repeated. You need to know more information... Would we get it? Do they survey exactly the number of cars on the road whether or not? I don't know... because we can certainly find police numbers and... How many speed cameras are... Maybe we can find the information how many cars there are on the roads through vehicles registrations. And maybe we can look at the number of convictions for drink driving, the number of convictions for people driving without licence or without insurance, people being less responsible about their driving. Maybe a lot of people do drive without insurance and tax, and while drinking. I think you need to look at some more figures. To try and predict whether that is realistic whether it will actually go down.*

Joy reconstituted a range of questions which might have motivated her response on the questionnaire. During the *recall* she continued questioning and conjecturing about the trend of the graph using her knowledge about road traffic in Warwickshire. Joy seemed to reinterpret the data and her answer justifying why she did not respond to the item which asked about how realistic the targets were (item 3 of the road accidents questionnaire task).

The *recall* also served to identify aspects from the questionnaire answers for which participants did not remember what the thought process was. For example, in the following extract from Teresa's interview she commented about the graph produced (item 2 of the road accidents questionnaire task).

T – *Oh yeah, I see... I did that on the bottom* [she produced a bar graph in which bars the children figures were on the top]. *And then I don't know if I was quite right. I think if I did this again I would done at the bottom like this* [pointing to the bottom of the graph, moving like a line] *putting the children at the bottom because you can actually to compare them like that ... But I didn't for some reason... can you see what I mean?* [Showing to the researcher]

R – If you put down there you can compare the...

T – Yeah, you compare the children as well. Although that is not going that much difference because the numbers here, because the scale of the graph...

R – Is it different?

T – Yeah... it's a kind of much smaller... There were all smaller than hundred...

R – Because the highest number is 66 [for children]...

T – Yeah, for some reason I put minors up here... I am not quite sure why... [Laughing]

During this *recall* some participants compared the two graph tasks. The following extract from the interview with Alex illustrates this.

A – I found these graphs [road accidents] *very easy to understand, a lot easier than other graphs, because obviously I used to read pie charts and bar graphs. It is just a lot more comfortable to use them because we were taught them at schools... you know, at an early age and then I just get comfortable with them after a while... I don't know... using them ... and we can see them all the time in the news and things.*

R – Did you find confuse the other graph [contraception-fertility] *or it was ok?*

A – The other graph was slightly confusing but after looking at it ... Hum, because I'm used to reading graphs because I'm been reading graphs now since... well since primary school. Just look at it, look at the labels and the axes and things and then just interpret the data. So you just look at it carefully and interpret any graph, I think.

The *recall* of the questionnaire answers related to the road accident graph also served to reflect about the process of interpretation of graphs such those presented to them. The following extract from the interview with Julia is an example.

R – Anything that you want to comment if you want, about this task, this interview.

J – Yeah. It got me thinking to be honest about them... I don't think... I'm normally quite critical at things anyway...I don't know if I'd pay much attention... I probably just look at it if it was in like the newspaper or something... look at it at a glance I probably wouldn't... If I was studying I wouldn't notice things like that... so. [Pointing to the babies pictures on the contraception-fertility graph]

R – Even though you are critical.

J – Yeah, I just said that... I was quite... Yeah. I probably would have bypassed it and say oh... I looked at the pictures, and then the same time sort of glancing at it... and not taking in really what it was trying to say... like that picture there, and that... I wouldn't do that line. It is quite funny really.

R – These graphs came from a reporting of Warwickshire.

J – Hum. Quiet and lively Warwickshire! Must be a nice place to live there. Maybe the best place to live in 10 years time or 20 years time then there will no casualties on the road and it will be a very safe place to live.

This *recall* part was followed by the last part of the interviews which is discussed in next section.

7.8 Opinion about the tasks and if they had experience in data handling in their placement.

In the last stage of the interview I tried to establish a connection between the research session and graphing teaching. Therefore I asked questions which invited the participants to comment about graphing teaching and research tasks used in the interview.

From the data analysis I could identify three main aspects mentioned by the participants: analysis of the research tasks; perspectives on graphing teaching, and suggestions of pedagogical activities.

Generally speaking the participants recognised that the graphs used as research tasks would not be appropriate for teaching younger primary pupils. The following extract from the interview with Frank illustrates this type of comment.

F – Hum, I think it is a quite good activity for older primary school children, for a kind of 8, 10 to 11, that sort of age. I am going to teach probably primary school children and probably I will teach secondary school as well, but certainly I mean this one here [road accidents graph] is fairly advanced, sort of high level, but it's quite good because you get to think actually critically about the graphs and actually they can think beyond the graph rather look at the face value. And then I think it's a quite good activity for older primary school at least.

Despite his previous comments about the nature of graph as factual data (see previous extract from Frank's interview in section 7.5 on page 165), in this part of his interview Frank suggested that graphing teaching is relevant in making students think critically about the data.

Betty also suggested that pedagogical graphing activities similar to those which comprised the interviews would be useful to make students think about the data.

However, she emphasised the need to make available information which would enable them to interpret the graph satisfactorily (see interview extract below).

> *B – (...) I think it is good they are taught data handling... and I think it is very good that they can read and understand data because not everybody can... and it can be quite confusing... I think it is also good if from statistics like this they can actually learn from it and think: "well, yes this is how many children in Warwickshire die or are seriously injured every year" and make them think about why this happens and think about the numbers and think about how these figures can come down which makes them think about how they live. I think that's very useful. But also I think it is very good for children to question the information that they get. And I think sometimes it is very easy for everybody to look at information like this and think that it is absolutely right and not question it, and not wonder who has... who's compounded the information. Do they have any interest in making you think a particular thing? And to just question it, and ask like we did, ask things don't just accept it. And I think it's as important for children to learn to do that as it is to actually use the data.*

Another aspect which I could recognise from the participants' interviews referred to their conceptions of graphing teaching. For example, Max emphasised graphing as cross curriculum skill.

> *M – Oh, yeah. Hum... In my opinion then, I think... it can be important... I mean, it's like a transferable skill: graph reading. You can use it whatever you are. Science, Maths... I mean, like you look at graphs on paper. So, I mean they need to know about that but these particular ones... I mean they can be useful for the fact that they can bring up... like other things that you brought up in this questionnaire I mean the fact of ... is such involved sort of what children... should they ask... I mean it is helpful in that perspective but it is not helpful in like in technical examples of the graph.*

Max seems to be concerned about the potential teaching activities which focus on technical aspects of graphing.

On the other hand, Teresa emphasised that graphing tasks similar to those developed in this study are interesting because they approach mathematics teaching in a practical way.

> *T – I think, it's really good... I guess because you want to do two different things... you want to teach how to read a graph, and what it says... so it is a kind of one thing just ask them saying...That's one thing and then other thing... you know, it just says... it does mean... where's the sample from... what do they mean by the particular word and stuff... But this may help... children to see things. Because sometimes people think: "oh, might Maths... oh..." That means has to be to straight like this kind of thing [showing the two road accidents graphs]. But here is a kind of...there it's a sort of useful*

way... I don't know... it's a practical way to learn... maybe... I think... it is a good way of... doing this kind of thing with children is a good way to think around things... to think more widely what they are looking at and questioning, question what they are looking at as well... Maybe if they use just this kind of graph [showing the road accident graphs] *they would not ask so many questions... perhaps... maybe.*

Teresa emphasised that graphing activities should be used to teach how to question and think around data. She also emphasised that activities similar to the research tasks could be a practical and informal way to teach mathematics.

In this part of the interviews some participants also described and analysed their teaching practice in graphing. For example, Val mentioned that she has been engaged in activities which also involved a topic related to traffic.

V – It is really good, yeah. I actually did a transport survey in my last placement car traffic on the roads... They weren't actually on the road. They were in two groups, and they had to record what they saw and they were close to a very busy road and they started to look at all the heath safety issues and actually... hum...asked them to plot a graph to show what types of transport they're only seven year-olds... six-seven year-olds... and it was a quiet time of the day we asked them to think about what levels that the traffic would be at 8 o'clock in the morning and we went 2 o'clock in the afternoon. So it got them thinking about how the graph might look differently... so yes definitely I think it's good, a good way of looking at it.

Hillary also gave other example of themes which might be related to the social in contexts which children participate.

H – I think that... When you doing data handling with children you've got to be... I think it is important to them to know how the information is being collected. And where did you get the information from? You've got to tell children...that you can't just... If for instance you were collecting information on farm animals, the number of young produced by farm animals, if they are collecting information on that they've got to look at a broad range of animals. They can't just be selective and choose one because they like it. And they have got to look at and consider every thing in the whole picture. In order to get a good idea what's going on, whatever topic you are looking at with them... Yes, and be careful to choose... data handling that's going to interest them as well... something that they will enjoy... not to give them something that is going to be quite boring for them to collect, and so it need to be subject rated. And also clear. Clear representation and not something that's going to confuse them... Because I must admit that after the two graphs that I looked at... This one is a lot clearer [road-accidents] ...Than that one [Contraception-fertility] *It is strange... Because that there is a diagram involved in that...But I'm still finding that easier [road accidents] to read. Sometimes these bar charts are quite straightforward for children to read.*

I asked Alex what his experience with graphing teaching during his placement was. Alex suggested that similar tasks could be used to assess children's knowledge related to graphing.

> *A – Hum, it was quite good because I am quite comfortable in my own knowledge in data handling and I am quite comfortable in using data. So I can actually put across to the children and they became... After a while they became confident... there's still a few children who didn't like doing it. Simply because they couldn't read the graph properly or they couldn't draw pictograms accurately enough. When I did bar charts... they all managed to do the bar charts quite easily. Because they just... they'd been taught it previously as well. Bar chart is just a thing that children get on quite well with early on, and I think they're very easy to understand when you try and interpret and read them.*

Liz also described her experience with graphing teaching. She particularly highlighted the integration of graphing with ICT sessions.

> *L – Hum. I did a bit yes. I was in year 2. So it's a very limited one to do them. They'd really not been taught graphs before but they had a go at making a bar chart for their favourite fruits. And then they could say what was higher, what was lower in the graph. So they have quite basic ability. And then we use computers, I did in ICT too, kind of look at graphs and... like different houses they did cross graphs looking at different houses and then another graph where they can click and drag grand parents and other family members to see how many years they have and things like that... and compare them which was quite good I enjoyed doing that. They're not really into the meaning of that... decreases and increases like things there... and they do a bit... how easy how they don't have any knowledge about other graphs perhaps they don't see them... they don't look at magazines like The Economist and read the graphs like that. But they don't see them everyday so they're not used to doing it.*

7.9 Discussion of the findings from the interviews

The analysis of data which came from the interviews provided a more complete picture of the elements and processes related to the participants' interpretations of media graphs. The face to face situation allowed me to ask questions clarifying aspects of participants' interpretation. The videotaping provided additional aspects of their interpretations such as intonation and body language.

The "reading the data" and "reading between the data" questions required a reading of the data displayed on the graph. On the other hand, the "reading beyond the

data" motivated a certain destabilisation of the participants' approach to the media graph tasks because these questions did not have a specific answer and requested the consideration of data which was not displayed on the graph.

The "reading beyond the data" questions required the development of interpretations which combined the analysis of the graphical trends displayed and participants' previous knowledge and experiences about the data. However, the type of question did not determine the process of interpretation because it seemed that other factors were involved. For example, even for "reading beyond the data" questions, Alex, Max and Emma did not make many comments which exhibited more explicitly the components of their interpretations. The influence of personal aspects (e.g. Alex seemed timid and Max was concise in his comments) as well as circumstantial factors (e.g. Emma seemed to rush to answer the questions because it was her lunch break time) might be considered. Those factors made each interview unique.

The interpretation developed by the participants needs to be considered in relation to the context of the research interview. For example, this context is not the same as *reading contexts* in which participants might usually have access to media graphs. Unlike interview situations, when participants are reading media publications they do not necessarily need to focus their attention on a particular graph for long, answering or asking specific questions in a specific way.

The research tasks given to the participants seemed to be similar to those interpretations of graphs developed in *school contexts* in which in order to compose a pedagogical activity, media graphs are extracted from media publications. However, unlike the group activities developed in *school contexts*, in these interviews the participants were engaged in a more personal interpretation of the media graphs.

The *recall* of questionnaire responses gave an opportunity for the participants to reconstitute, review and extend their interpretation. The participants' reanalysis also illustrated how limited written answers in a questionnaire could be compared to oral interpretations of the graphs.

The analysis of interview data indicated that the way of asking for predictions from the data helped the students in building an interpretation that involved an interaction with the data. It seemed that, as the participants worked through the interview, the media graph became more transparent to them. They seemed to be aware that technical knowledge about the interpretation was not enough to answer the questions.

The use of interviews provided a collection of comprehensive data from the participants' interpretations of media graphs and showed clearly the connection with the person. The analysis suggested a process of *mobilisation* of components which comprise *critical sense* in graphing such as:

1. *Mathematical knowledge*: the participants mobilise their knowledge related to mathematical notions and concepts associated with the graphical representation, such as: numerical and quantitative relationships, and notions of measurement and geometry.
2. *Contextual reference*: The participants contextualise the data displayed on the graph making references which are related to their formal knowledge in different areas (e.g. geography, health care, sociology) and their opinion (e.g. personal view about governmental campaigns of contraception or traffic safety).
3. *Affective exhibition*: The participants explicitly express aspects of their emotions and feelings related to scepticism, sarcasm, anger or hope in relation to the data interpreted.
4. *Personal exemplification:* The participants exemplify and justify their answers based on previous and personal experiences related to the data displayed.

The *mobilisation* of previous elements seems associated with an *emergence* of new and different meanings which are connected with the current process of interpretation.

The apparent confusion which the processes of *mobilisation* and *emergence* seem to produce during the interpretation needs to be managed by the interpreter. Therefore, *balancing* is another key process related to the notion of *critical sense* in interpretation of media graphs.

7.10 Summary of chapter 7

- The interviews explored aspects of the elements and processes involved in *critical sense* in interpretation of media graphs.
- 13 British participants were interviewed.
- The interviews comprised: briefing; questions about the contraception-fertility graph; questions about the road accidents graph; the recall of questionnaire responses; and debriefing.
- The interviews were comprised of media graphs tasks which explored three types of questions: "reading the data", "reading between the data", and "reading beyond the data".
- The data gathered from the interviews gave a better specification of the elements involved in *critical sense* in interpretation of media graphs: mathematical knowledge, contextual references, affective exhibitions and personal exemplifications.
- The interview also provided more comprehensive data about the processes related to *critical sense* in interpretation of media graphs.

Chapter 8

Discussion

8.1 The starting points

As discussed in previous chapters of this thesis, my initial interest in investigating the interpretation of media graphs was associated with the possibility of approaching the relationships between *out-of-school* and *school* mathematical understanding (see Figure 1.1 in chapter 1). Therefore I intended to bridge gaps between different forms mathematical knowledge use.

From the literature review I could identify several studies that emphasised the interpretation of graphs as a complex process which involved cognitive and non-cognitive aspects (e.g. diSessa, Hammer, Sherin, and Kolpakowski, 1991; Swatton and Taylor, 1994; Ainley, Nardi and Pratt, 2001; Roth and Bowen, 2001; Arcavi, 2003). In addition, a number of studies in statistics education conceptualise statistical literacy as comprising relationships between mathematical and statistical knowledge and other elements such as beliefs and affective factors (e.g. Evans, 1992; Gal, 2002).

It seems a great challenge to approach such a complex range of elements related to the interpretation of graphs. For example, McKnight (1990) assessed individual competencies in the critical evaluation of graphical arguments with survey procedures. She argues that high schooled participants did not find it difficult to *observe facts* and *relationships* in graphical data. However, the *interpretation of relationships* and *evaluation of the value* of the graphical data seemed complex and problematic tasks. McKnight, Kallman and Fisher (1990) find it difficult to label as "erroneous" certain participants' answers which are linked with personal beliefs and emotional reactions. McKnight and her colleagues recognise that such complex tasks must be investigated with qualitative data from interviews in order to have details of the participants' interpretation.

As discussed in chapter 2, McKnight's approach is related to other studies which investigate assessment tasks in the interpretation of graphs which were composed of three levels of questions (e.g. Curcio, 1987; Watson, 1997). Friel, Curcio, and Bright (2001) discuss these studies emphasising that they have a common classification which is associated with three levels of questions which required specific skills of interpretation of data. The *elementary* question level requests extraction of information from the data (*reading the data*). The *intermediate* questions level needs that the reader find a relationships in the data (*reading between the data*). Finally, the *overall* question level which requires to move beyond the data (*reading beyond the data*).

Following the discussion of previous studies I decide to use this typology of questions in the interviews. The findings from the interviews suggested that the "reading beyond the data" questions provide an opportunity for participants to use more than mathematical and statistical knowledge related to the data. Therefore, they also drew on their personal experiences and knowledge related to others aspects of the data interpreted.

However, I would like to emphasise some of specific aspects of the use this typology of questions in the present study. Unlike previous research, in this study I did not use this taxonomy to trial pedagogical assessment tasks which classify students' performance in interpretation of traditional school graphs (e.g. Curcio, 1987). I also did not use the "beyond the data" questions to assess the students' skills in identifying mistakes or misleading elements in media graphs (e.g. Watson, 1997).

The present study used the "beyond the data" questions in interviews in which the participants could interact with the researcher in order to respond to the tasks. Therefore when the participants were answering the questions they could develop more explicit interpretation of the media graphs than when answering multiple-choice items on written responses to open-end questions.

In this study the use of "beyond the data" questions was particularly important to investigate the notion of *critical sense* as related to the processes of *mobilisation*

and *balance* of several elements related to the interpretation of media graphs. I specifically explored *critical sense* in the interpretations developed by primary school student teachers. The choice for these participants was mainly related to the aim of investigating the process of interpretation among those who will deal with the challenges of teaching about graphing.

The development of the notion of the *critical sense* in interpretation of media graphs followed several stages of elaboration through the literature review and the analysis of empirical data. Initially I emphasised *critical sense* as being related to the sceptical interpretation of media graphs. This conceptualisation was influenced by researchers and curriculum makers who emphasise that mathematics and statistics teaching should enable students to critically evaluate and comment on statistical information, arguments and messages (Gal, 2002). For example, Watson (1997) emphasises that students who have a high level of statistical literacy should be able to criticise unrealistic claims made by the media.

At the stage of the pilot study I conceptualised *critical sense* as an ability to look behind the data and deeply analyse information and its interrelations rather than simply accepting the initial impression given by the graph (Monteiro and Ainley, 2002, 2003a, 2003b). However, two important aspects emerged from the discussion of the pilot study findings. Firstly, whilst the research tasks were intended to explore sceptical aspects of the participants' interpretation, I could identify that a complex range of elements were also involved, for example non-cognitive factors such as personal expectations about the data. Secondly, when the participants were interpreting the media graphs they also seemed to *balance* the elements *mobilised* in order to answer the tasks.

After the analysis of the pilot study empirical data related to the participants' interpretations of media graphs, discussions with colleagues and the audiences of conferences in which I participated, and from further reviews of other studies, I developed a wider perspective of *critical sense*.

These reflections from the early stages of the present research served to elaborate and develop the main study data collection which intended to explore the *elements* and *processes* of *mobilisation*, and *balancing* related to *critical sense* in interpretation of media graphs.

The discussion moved from *critical sense* as a skill or ability, to *critical sense* as a process which can emerge in the interpretation of media graphs. This emphasis on the processes of *mobilisation* and *balancing* of elements involved in *critical sense* also emphasised the role of the person interpreting the graphs. Therefore *critical sense* is viewed as a crucial process related to a self-evaluation of the interpreter who needs to *balance* the knowledge and experiences *mobilised.* The reader needs to take a critical approach to the whole process, including him/herself. Therefore, *critical sense* also comprises the sensitivity of readers to examine their own ideas, beliefs, feelings, conceptions, and conjectures about the data being interpreted. The term '*sense*' is used to emphasise this broader dimension of *critical.*

The exploration of processes involved in the interpretation of media graphs also emphasised the discussion of the contexts of interpretation. As discussed in chapter 2 and 3, the graph can be conceptualised as cultural mediator used to display and understand data in three main contexts related to the interpretation of graphs: *enquiry*, *reading* and *school.* This research highlights the importance of characteristics of *school contexts* and clarifies the interaction with other *contexts.* The *school contexts* differ from *enquiry contexts* where readers of graphs predominantly use theoretical and academic mathematical knowledge (e.g. mathematicians and statisticians in their laboratories).

The *school contexts* are also different from *reading contexts* where the use of graphs is associated with non-academic processes of interpretation of graphs. In *school contexts* questions about the graphs are set externally, and these questions draw attention to particular aspects of the data, where in the other contexts questions arise internally.

Generally it is expected that in *school contexts* the processes of teaching and learning about graphs make references to both mathematical elements from *enquiry contexts* and understanding of data in *reading contexts*. However, these interfaces between *school contexts* and *enquiry* and *reading contexts* seem very complex and an important challenge to mathematics education.

8.2 The main study

The partial literature review and the discussions of pilot study were used in the development of the main study. The aim of the main study explored *critical sense* in interpretation of media graphs among a larger number of participants with different backgrounds (undergraduates and PGCE students; British and Brazilians). The main study *interplayed* between two complementary datasets derived from questionnaires and interviews.

The questionnaire and interview situations had similarities and differences from *reading contexts* in the use of media graphs. For example, in *reading contexts* the interpretation of media graphs is an individual activity in which graphs are associated with written texts. Although, this surrounding written text might be related to the topic of the graph, generally in media publications they do not refer directly to the graphs.

On the other hand, the main study tasks had more similarities with *school contexts* of interpretation of media graphs. For example, the graphs were extracted from media publications and used in pedagogical tasks which comprised specific questions.

The analysis of the participants' interpretations of media graphs involved responses to questionnaire items which were considered in relation to a number of factors.

The questionnaires requested the participants' written answers. This procedure probably restricted the inclusion of elements which comprised the participants' full interpretation of the media graph tasks. However, from the analysis of their written responses I identified some important aspects:

- Despite difference in academic and cultural backgrounds among British undergraduates, PGCE students and Brazilian undergraduates there was no great difference between patterns of response frequency.
- The participants' responses did not seem to be determined by the way in which the data was displayed on the graphs.
- The majority of statements were explicitly connected with the participants' opinions and conjectures about the context of data (e.g. social and economical factors involved, and data collection).

The questionnaire items did not emphasise technical or mathematical interpretations of media graphs (as generally happens in *reading contexts*), but the participants' statements gave evidence of the consideration of numerical and quantitative relationships and the analysis of the technical composition of graphs (e.g. comments about the relationship between contraception percentages and fertility rates, and observations about the scale of the road accidents graphs).

The analyses of questionnaire responses indicated aspects discussed by Ainley (2000a) who suggests that the use of mathematical knowledge in certain out-of-school situations tend to be broad and fuzzy. For example, concerns about reliability of data and technical issues could be inferred from the participants' questions about methods to gather the data displayed on the graph.

From the analysis of the participants' responses I identified that scepticism about the data also seemed to be implicit rather than specifically addressed in their responses. On the other hand the data gathered from the questionnaires did not give much evidence about the affective components of the participants' interpretations of media graphs.

Generally, the analysis of questionnaires supported evidence of the *mobilisation* of several elements related to *critical sense* in interpretation of media graphs. However, the questionnaire responses comprised a dataset which would complement

and be complemented by the interview dataset which gave different evidence of elements and processes.

The participants' responses to "the reading beyond the data" questions confirmed aspects discussed in previous studies (e.g. Friel, Curcio, and Bright, 2001). However, the way of questioning and the type of graph used in the interviews suggested other elements to this discussion requiring this type of question. In the interviews the participants seemed to use the graphs as mediators to analyse the data related to the topic presented as it is displayed. Therefore they were not only technically reading or criticising the data, but they were using the graph to develop a wider understanding of the data.

In some way the use of media graphs in research situations provides opportunity for the participants also to reflect on the social context. This process of *transparency* which emerged from their interpretation allowed them to see more than numbers related to contraception, fertility or road accidents, they saw the situation in which women and children (and themselves) were involved.

The participants verbalised their thoughts, opinions, explanations and feelings about the data represented, self-reflecting their own knowledge and reactions when interpreting the graphs. The data gathered from the interviews also gave evidence of the participants' affective engagements by expressions such as sarcasm, jokes, laughs, scepticism and even indifference involved in their process of interpretation.

This complex process brought elements which could confuse their interpretation (as like observed by Cooper and Dunne, 2000). However, the *mobilisation* was also followed by a balance of these various elements. For example Hillary (see subsection 7.6.3 of chapter 7) seemed to try to see the targets as realistic because it would be safer for her and her children, although she recognised that it would be unlikely they could be met considering the trend displayed on the graph and her knowledge about the social context.

In chapter 7 I gave examples of the elements and processes related to critical sense in the participants' interpretations. A question could be made about the absence

of *critical sense*. I recognise that from the discussion of the participants' interview I could identify more the *presence* than the *absence* of *critical sense*. I related this to a number of factors. For example, the fact that all participants were volunteers who wanted to help me in my research, and therefore they seriously engaged in the given problem solving situation. At the period of the interviews they have also had recent teaching about data handling and some of them taught this topic in school placements. Maybe if I had an opposite situation for data collection in which the students were not motivated enough to participate (e.g. Chick and Watson, 2004) I could have evidence of the *absence* of critical sense.

An indication of a probable *absence* of *critical sense* occurred in Emma's interview when she was responding to "between the data" questions of contraception-fertility graph (see extract in subsection 7.4.2 of chapter 7). The fact that she was glancing at the data could contribute to her non-accurate answer. However, analysis of her interpretation indicated an attempt to *balance* elements involved.

8.3 The conclusive points

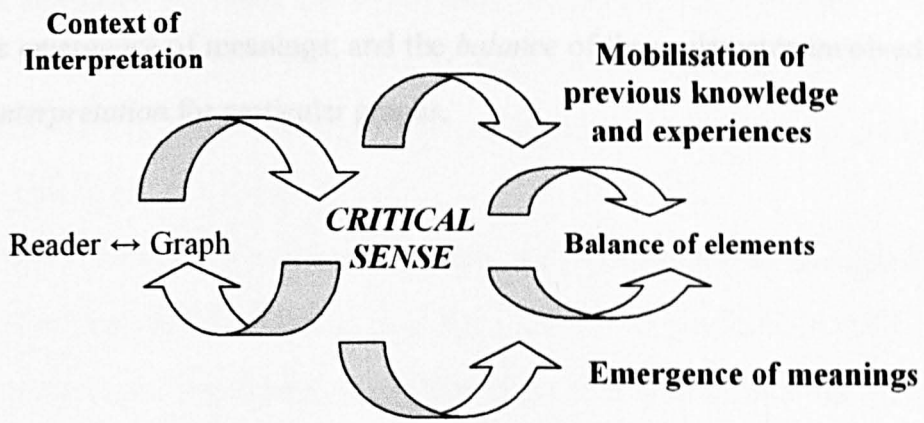
The data analysis indicates that it is quite difficult to fit the student-teachers' responses into hierarchical classifications which, for example, would make critical thinking the highest tier of sophisticated statistical literacy. In part, I argue that this is because the *Critical Sense* is dependent on contexts of interpretation.

The interpretation of media graphs is a dynamic process in which people interact with the data displayed. When people are engaged in interpretation they mobilise previous knowledge related to the actual facts or emotional experience of their lives. This knowledge and experience influences the reader's interpretation of the data displayed. Mathematical and statistical knowledge can be mobilised, as well as informal experiences. I use the term *mobilisation* to emphasise someone engaged in interpreting a graph not as 'transferring' knowledge and experiences from previous situations, but as triggering those elements for use in the current interpretation. In addition, the use of this knowledge and experience is not simply a question of direct

application, since mobilisation happens concomitantly with the emergence of the different meanings.

When I began this research project I was aware that the interpretation of graphs might be related to *school* and *out-of-school mathematical knowledge*, and *contextual reference* (see Figure 1.2). However, the data analyses developed in this study suggested a much more complex picture of the process of interpretation of media graphs. The notion of *Critical Sense* in interpretation is related to the *mobilisation* of previous knowledge and experiences, *emergence* of particular meanings and *balance* of the influence of these elements in interpretation (see Figure 8.1 below).

Figure 8.1: Elements and processes related to *critical sense* in interpretation of media graphs



From the analysis of participants' responses I could identify four different elements mobilised from which emerge different meanings in the context of interpretation of media graphs.

- *Mathematical knowledge*: participants mobilise their knowledge related to mathematical notions and concepts associated with the graphical representation, such as: numerical and quantitative relationships, and notions of measurement and geometry.
- *Contextual reference*: participants contextualise the data displayed on the graph making references which are related to their formal knowledge

in different areas (e.g. geography, health care, sociology) and their opinion (e.g. personal view about governmental campaigns of contraception or traffic safety).

- *Affective exhibition*: participants explicitly express aspects of their emotions and feelings related to scepticism, sarcasm, anger or hope in relation to the data interpreted.
- *Personal exemplification:* participants exemplify and justify their answers based on previous and personal experiences related to the data displayed.

Therefore *Critical Sense* is a central component of the interpretation process which is related to three dynamic processes: the *mobilisation* of previous knowledge and experiences; the *emergence* of meanings; and the *balance* of these elements involved in a *context of interpretation* for particular graphs.

Chapter 9

Final considerations

9.1 Learning outcomes

The development of the research discussed in this thesis provided important learning opportunities to improve my practice as a researcher. Among other aspects I especially emphasise the integration of the main research stages: literature review, data collection and data analysis. This contributed to seeing the research process more holistically. For example, the initial literature review generates the discussion of aspects which were approached in the pilot study data collection. However, the analysis of data motivated the expansion of the literature review which brought new elements to be approached in the main study. In addition, the fact that I reviewed studies associated with different areas and methodological-theoretical perspectives allowed me to evaluate my own approach.

The literature review was a continuous process which supported the theoretical and methodological analyses. The review of a large number of publications with a wide range of perspectives contributed to the formation of a holistic point of view about the interpretation of media graphs. For example, the attempt made to consider different perspectives of the conceptualisation was fundamental to understanding elements and processes of *critical sense*. The discussion of previous studies in interpretation of media graphs was also important in identifying the gaps which needed to be bridged.

The data collection and data analysis were developed as complementary phases which sometimes occurred simultaneously during the research process. This kind of approach allowed me to elaborate later data collection sessions according to aspects which emerged from analysis of data collected earlier.

9.2 Pedagogical implications

The discussion of findings from this present study also emphasises important pedagogical implications suggested by other authors. For example, I believe that this present study contributes to the recognition that interpretation of graphs is a key component in understanding data rather than mere perceptual decoding (as suggested by Arcavi 2003). On the other hand, the discussion developed in this study emphasises the limitations of approaches which suggests that accurate graphical representation leads to a correct reading of data (e.g. Tufte, 1997, 2001). Therefore, the fact that media graphs frequently present inaccuracy and misleading elements does not determine the reader's interpretations of them.

This study also offers elements to the discussion which criticises pedagogical approaches which emphasise the esthetical and decorative aspects of the use of graphs (e.g. Ainley, 1995), and those approaches which suggest the use of media graphs in *school contexts* without consideration of the implications of the relationships between *out-of-school* and *school contexts* (e.g. Adler, 1999; Ainley, 2000a). Therefore, I believe that this study contributes to these discussions which are related to a great challenge for primary school teachers: the development of teaching which integrates *out-of-school* scenarios in which children can use mathematics.

The notion of *critical sense* as a process rather than a skill also suggests that ways which readers *mobilise* and *balance* the elements of the interpretation do not seem directly "transferable". For example, Gal (2002) suggests that the same person can develop different processes of interpretation in different contexts. Therefore, it seems precarious research approaches which classify readers' interpretation skills according to their analysis in specific graph tasks.

Therefore bringing media graphs into the classroom as a pedagogical approach to teach graphing will not, in itself, embrace the complexity of the interpretative process which can be established by readers of media graphs. Although the analyses which come from one-to-one interviews cannot be generalised to conventional *school*

contexts, the findings of the present study suggested that the teaching of graphing should be based on opportunities to learn how to be aware of, to experience and to balance the diversity of elements involved in the interpretation of media graphs.

The consideration that the affective and cognitive aspects are interconnected in the process of interpretation of graphs highlights the importance for student teachers to be aware of the complexity of processes involved in the use and understanding of graphs. This also suggests that approaches to teaching graphing should allow pupils to be creative and express themselves, but also give the opportunity to experience the need to make a choice between balance of attention and those elements which comprise their interpretation.

9.3 Further research

Strauss and Corbin (1998) suggested that a *phenomenon* is a term that answered to the question "what is going on here?" (p.123). This study began to answer this question when it suggested the notion of *critical sense* in interpretation of media graphs. However, the present thesis might generate many other questions which should be investigated by later studies.

Although outcomes from this study can be used to inform teacher education programmes, I recognised that further research will need to identify aspects of learning and teaching processes which might help the development of *critical sense* in graphing. Therefore, I acknowledge that theoretical aspects discussed in this study need further development in order to support prescriptive suggestions in teacher education (as discussed by Lerman, 1997).

The findings of the present study provided elements for the discussion which highlighted that mathematics and statistics teachers' personal learning experiences influence their point of view and analysis of how students' learning (as suggested by Garfield, 1995). Therefore if teacher education offers opportunities to student teachers to experience the complexity of the process of interpretation of graphs it is probable that they might develop a similar attitude when teaching in school. Future research

should investigate and suggest ways to develop teacher education approaches which integrate the theoretical and practical aspects related to graphing teaching. For example, in the last part of the interviews (see chapter 7) I explored the participants' opinion related to their experience in graphing teaching. It seemed that the consideration of the participants' teaching experiences from their placement during the theoretical discussion in mathematics curriculum courses would be an important opportunity for the integration of graphing teaching theory and practice.

From my literature review I realise an almost complete exclusion of investigations which approach interpretations of graphs by students with special needs. I believe that investigations which approach this issue give important and different insights about the access and use of mathematics through the graphs.

This study particularly investigated *critical sense* in interpretation of media graphs. However, the discussion might be extended to other mathematical areas and topics where teaching might relate the use of other out-of-school resources as it does in graphing teaching with media graphs.

The process of *mobilisation* suggested in the present study also needs to be considered in future research. For example, it will be important to have more evidence about the possible influence of the readers' familiarity with the topic of data and/or with the graphical structure in the process of *mobilisation* of the elements which comprise the interpretation of graphs.

Another important element which needs to be investigated is related to the *context dependent* dimension of *critical sense* in the interpretation of graphs. This might develop further the understanding of the nature of *critical sense* and its pedagogical implications. For example, although the present study suggested that *critical sense* was not a skill or ability which could be applicable in any context of the interpretation of graphs, I recognised that graphing teaching might facilitate the learning of interpretative approaches which students could consider when engaged in other contexts of interpretation of graphs.

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Appendix 4.1 - Copy of the pilot study questionnaire

1. Participant Age: _____ years old

2. Do you subscribe to any newspaper or magazine, or other periodic publication? Which?

a. _____ How often do you read it?

b. _____ How often do you read it?

4. Do you read OTHER newspaper, magazines or periodic publication? Which ?

a. _____ How often do you read it?

b. _____ How often do you read it?

4. Do you have own computer? □ Yes □ No

5. Which type of activities do you do by computer? (Please tick)

Activity	How often?
Emails	□ Daily □ sometimes □ rarely □
Games	□ Daily □ sometimes □ rarely □
Sources	□ Daily □ sometimes □ rarely □
Chat	□ Daily □ sometimes □ rarely □
Text editors	□ Daily □ sometimes □ rarely □
Graphs and table editors	□ Daily □ sometimes □ rarely □
Other_____	□

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SEE ORIGINAL COPY OF THE THESIS FOR THIS MATERIAL

Appendix 4.3 - Sub-themes identified in the article *fertility rights*

Fertility Rights

Shereen El Feki

1st paragraph: (07 lines)

- 11/10/2001 was the pill's golden anniversary (created in a Mexican laboratory from native yams. 'How fertility is the field of contraceptive development?'

2nd paragraph: (10 lines)

- 'Pharmaceutical companies have lost their appetite'. 'World market for female contraceptives for birth control is worth $16 billion, or less than 5% of the total prescription drug market'.

Graph

3rd paragraph: (11 lines)

- Different targets in different parts of world: 'Rich world' = creeping old age and 'Developing countries' = still unwanted pregnancies and childbearing (e.g. 100 million unintended pregnancies each year).
- 'Women around the world need not only better access to existing contraceptives but also new methods better suited to their financial, cultural and physiological constraints'.

4th paragraph: (12 lines)

- Contraceptives are given to healthy people rather than to treatment of diseases like vaccines are used. Most drug companies have deserted the field because factors, such as: expensive and time-consuming tests prove their long- term safety and high risk of litigation. Just four main firms + few plucky biotechnology ventures keep commercialising + researching in contraception.

5th paragraph: (13 lines)

- This paragraph gives an example of contraception methods at Population Council of New York, which produce other health benefits, such as easier menstruation.

6th paragraph: (13 lines)

- This paragraph exemplifies more effective contraceptives such as spermicidal and micro-biocidal compounds and RV-486. It also discusses socio-politico and commercial difficulties which affect the contraceptive development.

7th paragraph: (19 lines)

- 'The male contraception is moving quickly'. The paragraph presents examples of research in MRC – Human Reproductive Sciences Unit (Scotland), and of Institute of Reproductive Medicine at University of Münster. It previews a progress in this area for 2002.

8th paragraph: (14 lines)

- 'Other approaches are in the works too', among them vaccines, and male oral contraceptive. The paragraph emphasises that men are more willing to shoulder the responsibility of contraception.

Appendix 5.1 - Summaries of the courses taken by the participants

British undergraduate participants
Module title: Curriculum Mathematics 2: Planning for the Primary Classroom
Year group: BA (QTS) Year 2
Year: 2002/3

Module Content: the module provided opportunities to:

- explore the development of concepts in geometry, measures and data handling;
- extend consideration of the number system and operations on whole numbers and fractions, particularly in the context of measures and data handling;
- extend understanding of the use of mathematical language and explore visual and graphical communication in mathematics;
- extend understanding of the use of learning resources in the learning and teaching of mathematics, including ICT;
- explore approaches to the assessment of pupil progress, including school-based experience;
- explore approaches to planning for individual phases within a lesson, differentiation of activities, and progression between lessons;
- introduce to models for short and medium term planning;
- revitalise and extend own subject knowledge;
- consider applications of mathematics in problem solving within and beyond the classroom, and the contribution which mathematics can make to the spiritual, moral, social and cultural development of pupils.

Module Delivery: There were six kinds of activity during the module:

- Lead lectures given to the whole year group.
- Workshops/seminars with group tutor.
- Study tasks carried out in non-contact directed time.
- School-based tasks carried out during school placement.
- Subject knowledge audits and associated revision activities.
- Optional revision sessions on aspects of subject knowledge (Summer term).

Directed time tasks: reading tasks, subject knowledge audit, and school based tasks (placement).

British PGCE participants
Module title: Core curriculum mathematics
Year: 2002/3

Programme objectives

- Give opportunity to the students to become efficient, effective and professional teachers of primary mathematics;

- Give opportunity to the students to consider their own mathematical thinking and place this within the context of learning and teaching primary mathematics;
- Introduce the knowledge, concepts and skills of mathematics as they relate to the range of abilities they will meet in children within the primary school, and early years and to provide them with knowledge and understanding of the Mathematics National Curriculum (1999);
- Introduce the students to the Qualifying to Teach non statutory guidance for Mathematics;
- Provide the students with the insights and experiences which will enable them to produce coherent forward plans demonstrating the need for continuity and progression in pupils learning, and how to translate these into plans for lessons and activities drawing on suitable teaching strategies;
- Give opportunities to the students to become aware of, and critically sensitive to, the large range of resources, both text-based and computer-based, available to the mathematics teacher and the cognitive benefits arising from the judicious selection and use of mathematics resources, including ICT;
- Introduce the students to the various ways in which they may identify children's levels of attainment using summative, formative and diagnostic assessment, and to consider the ways in which they may utilise these assessment procedures to inform teaching, improve learning and report to others;
- Give opportunities to develop a teaching style which suits personal attributes and experiences;
- Help the students to achieve the required standards for QTS related to mathematics subject knowledge and for the national numeracy test for all ITT students.

Directed Tasks: Study tasks to carry out in directed time, and school based tasks (placement)

Brazilian undergraduate participants
Discipline title: Methodology of mathematics teaching
Total duration: 60 hours
Semester: 1/2003
Objectives: Study of aspects of mathematical concepts

- Epistemological aspects: historical development and epistemological obstacles;
- Didactical aspects: teaching sequences; problem situations; didactical obstacles; and analyses of teaching contexts;
- Cognitive aspects: development of concepts by the individual and processes of teaching and learning related to the concept of number, additive structures in pre-school, fundamental school and education of adults.

Assessment: participation in classroom activities; development and analysis of research; seminars and oral presentations; written exams. The main aim of the assessment process is to evaluate the analytical skills used in assessing school text books and teaching situations, and plan didactical sequences.

Appendix 5.2 - Copies of main study questionnaires
(British undergraduates' background)

1. Gender: □ Male □ Female 2. Age: _____ years old

3. Specialism: .....

4. What type of written text do you read more frequently? (e.g. news reports, fiction, academic papers etc) And how often do you read it?

5. What do you like to read?

6. Do you subscribe to any newspaper or magazine, or other periodic publication? Please write down all that apply.

7. Do you read OTHER newspapers, magazines or periodic publications and to which you do not subscribe? Please write down all that apply.

8. Which type of activities do you do by computer? (Please tick)

Activity	Daily	Weekly	Monthly	Never
Emails	□	□	□	□
Games	□	□	□	□
Search Engine (e.g. Yahoo)	□	□	□	□
Chat	□	□	□	□
Words Processors	□	□	□	□
Spreadsheets	□	□	□	□
Other_____	□	□	□	□

9. What is your highest mathematics qualification? □ 16 + (GCSE or CSE or 'O' level)
□ 'A' Level
□ Other.....

(British PGCE students' background)

1. Gender: □ Male □ Female 2. Age: _____ years old

3. First degree: .....Where? ..... When?.....

4. What type of written text do you read more frequently? (e.g. news reports, fiction, academic papers etc) And how often do you read it?

5. What do you like to read?

6. Do you subscribe to any newspaper or magazine, or other periodic publication? Please write down all that apply.

7. Do you read OTHER newspapers, magazines or periodic publications and to which you do not subscribe? Please write down all that apply.

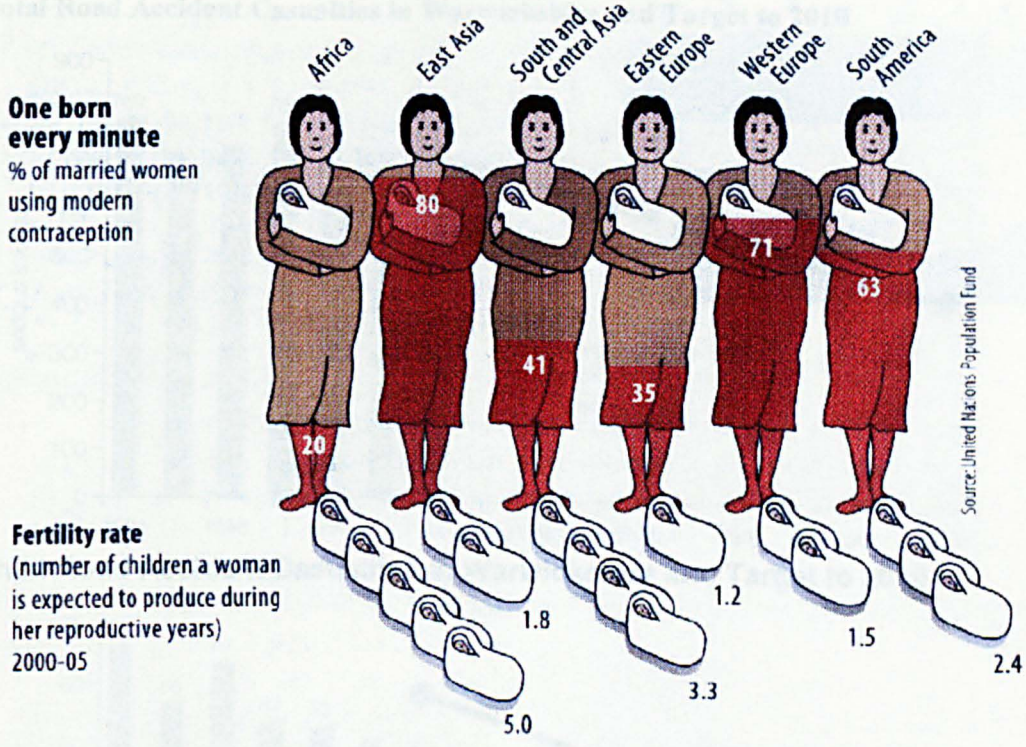
8. Which type of activities do you do by computer? (Please tick)

Activity	Daily	Weekly	Monthly	Never
Emails	□	□	□	□
Games	□	□	□	□
Search Engine (e.g. Yahoo)	□	□	□	□
Chat	□	□	□	□
Words Processors	□	□	□	□
Spreadsheets	□	□	□	□
Other_____	□	□	□	□

9. What is your highest mathematics qualification? □ 16 + (GCSE or CSE or 'O' level)
□ 'A' Level
□ Degree □ Other.....

10. Did you attend to Statistics Course on your degree course? □ **YES** □ **NO**

If **YES** which topics did you study?



Graph reprinted from *The World in 2002, The Economist, 2001, p.132.*

1. Write one or two sentences about a **positive** message, which could be given by this graph.

➢

➢

2. Write one or two sentences about a **negative** message, which could be given by this graph.

➢

➢

3. If you could talk to the person that produced this graph, are there any questions you would like to ask?

➢

➢

➢

➢

➢

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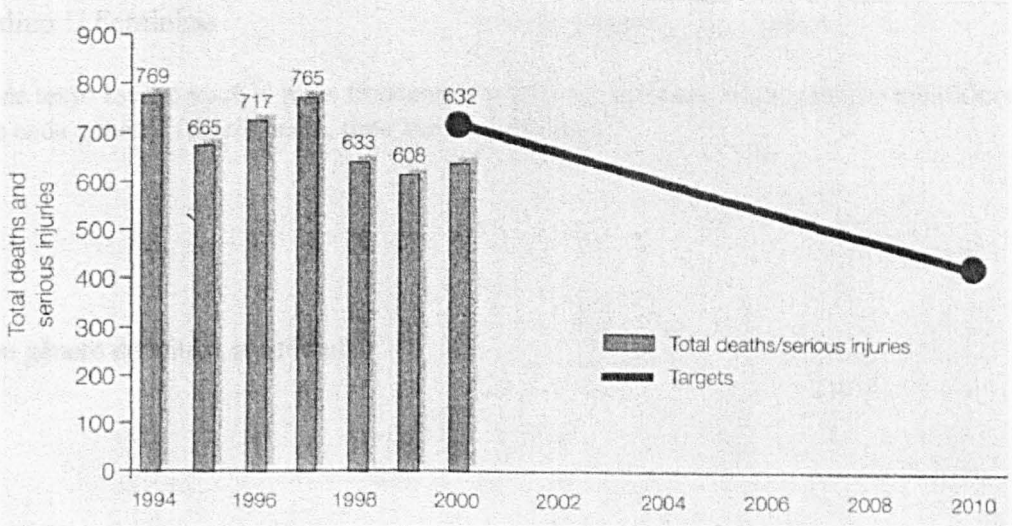
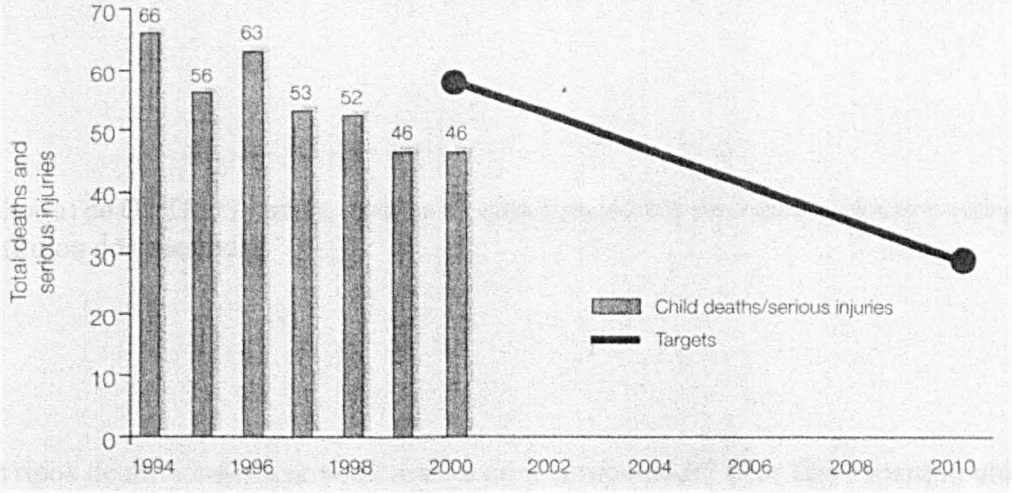
Total Road Accident Casualties in Warwickshire and Target to 2010



Child Road Accident Casualties in Warwickshire and Target to 2010



Graphs reprinted from *Quality of life in Warwickshire*, September 2001, pp. 93-94.

1. If you could talk to the person that produced this graph, are there any questions you would like to ask?

2. If the information from these two graphs were combined what would graph look like? Please draw it.

3. Do you think that these targets are realistic? Why?

Please, could you provide contact details? Email: Phon

(Brazilian undergraduates' questionnaire in Brazilian Portuguese)

1. □ Masculino □ Feminino 2. Idade: _____ anos

3. Que tipo de texto escrito você lê mais freqüentemente? (e.g. notícias, ficção, artigos científicos etc) Qual a freqüência de leitura de cada gênero? (diariamente, uma vez ao mês etc)

5. Qual o seu gênero de leitura predileto?

6. Você é assinante de algum jornal, revista ou algum outro periódico? Por favor, escreva os títulos dos mesmos?

7. Você é leitor(a) de OUTROS jornais, revistas ou outros periódicos dos quais você não é assinante? Por favor, escreva os títulos dos mesmos?

8. Quais os tipos de atividades que você realiza com computador? (Por favor marque um "x")

Atividade	Diariamente	No maximo três vezes por semana	Raramente	Nunca
Emails	□	□	□	□
Jogos	□	□	□	□
Pesquisa (ex. Yahoo, Cadê)	□	□	□	□
Bate-papo	□	□	□	□
Textos (ex.Word)	□	□	□	□
Spreadsheets (ex. Excel)	□	□	□	□
Outro _____	□	□	□	□

9. Você estudou estatística em algum outro curso (ou disciplina) anteriormente? Especifique quando e onde?

10. Se você gostaria de participar de outro etapa dessa pesquisa, por favor escreva seu email ou endereço para correspondência abaixo:

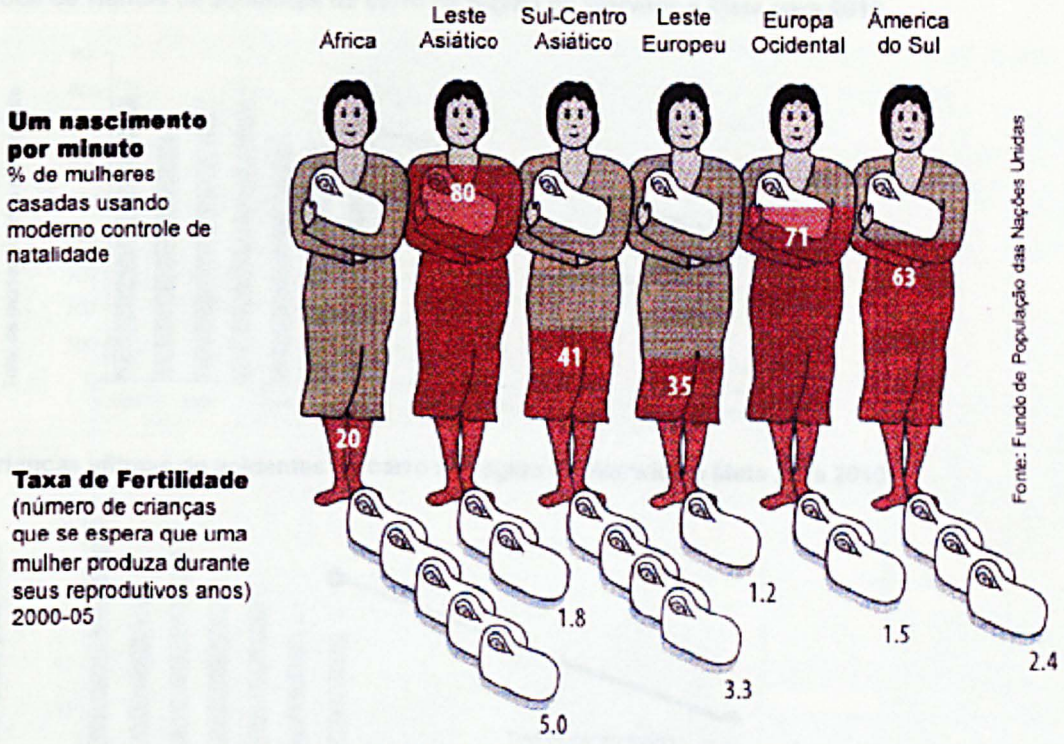


Gráfico reproduzido e traduzido da revista *The World in 2002, The Economist, 2001, p.132.*

1. Escreva uma ou duas frases que explicitem mensagens **positivas** apresentadas pelo gráfico.

➢

➢

2. Escreva uma ou duas frases que explicitem mensagens **negativas** apresentadas pelo gráfico.

➢

➢

3. Se você pudesse falar com a pessoa que produziu o gráfico acima, quais seriam as questões que você perguntaria a respeito deste gráfico?

➢

➢

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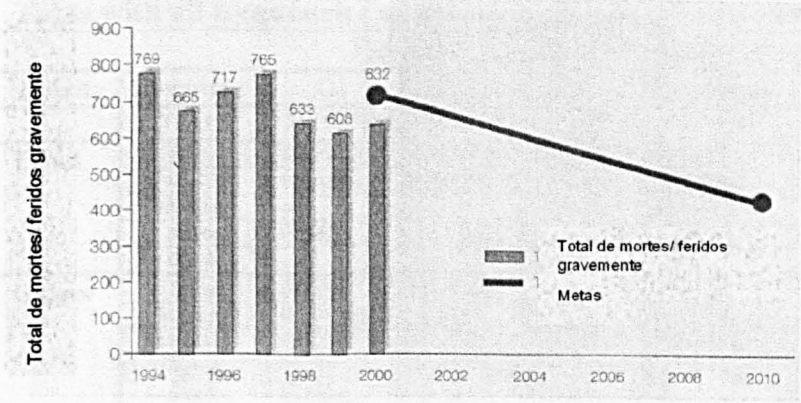
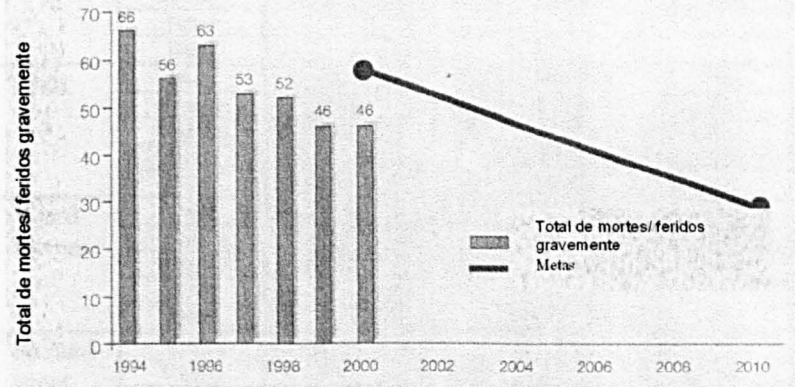
Total de vítimas de acidentes de carro na região de Warwick e Meta para 2010



Crianças vítimas de acidentes de carro na região de Warwick e Meta para 2010



Gráficos reproduzidos e traduzidos do Relatório *Quality of life in Warwickshire*, Setembro 2001, pp. 93-94.

1. Se você pudesse falar com a pessoa que produziu os gráficos acima, quais seriam as questões que você perguntaria a respeito destes gráficos?

2. Se as informações destes dois gráficos fossem colocadas juntas num unico gráfico, como seria esse gráfico? Desenhe abaixo.

3. Você acha que as metas apresentadas pelos gráficos sao realistas? Por que?

Appendix 6.1
Table with all frequencies of British participant's answers to pre-coded items

Frequency of use of computer in some activities

Activity	Frequency	G1	G2	G3	Subtotals	GM	GA	Subtotals	TOTAL
	TOTALS	26 (100%)	17 (100%)	21 (100%)	64 (100%)	27 (100%)	27 (100%)	54 (100%)	*118 (100%)*
Email	Daily	14 (54%)	15 (88%)	09 (43%)	38 (59%)	17 (63%)	10 (37%)	27 (50%)	65 (55%)
	Weekly	11 (42%)	02 (12%)	09 (43%)	**22 (34%)**	10 (37%)	15 (56%)	**25 (46%)**	47 (40%)
	Monthly	---	---	02 (10%)	**02 (3%)**	---	02 (7%)	**02 (3%)**	04 (3%)
	Never	01 (4%)	---	01 (4%)	**02 (3%)**	---	---	---	02 (2%)
	Blank	---	---	---	---	---	---	---	---
Games	Daily	01 (4%)	02 (12%)	-	**03 (5%)**	-	01 (3%)	**01 (2%)**	04 (3%)
	Weekly	07 (27%)	05 (29%)	02 (10%)	**14 (22%)**	03 (11%)	01 (3%)	**04 (7%)**	18 (15%)
	Monthly	06 (23%)	05 (29%)	11 (52%)	**22 (34%)**	14 (52%)	07 (26%)	**21 (39%)**	43 (36%)
	Never	11 (42%)	04 (24%)	07 (33%)	**22 (34%)**	09 (33%)	17 (63%)	**26 (48%)**	48 (41%)
	Blank	01 (4%)	01 (6%)	01 (5%)	**03 (5%)**	01 (3%)	02 (7%)	**03 (6%)**	06 (5%)
Search	Daily	02 (8%)	06 (35%)	05 (24%)	**13 (20%)**	08 (30%)	08 (30%)	**16 (30%)**	29 (25%)
	Weekly	20 (77%)	08 (47%)	11 (52%)	**39 (61%)**	16 (59%)	13 (48%)	**29 (54%)**	68 (58%)
	Monthly	04 (18%)	03 (18%)	05 (24%)	**12 (19%)**	02 (7%)	06 (22%)	**08 (15%)**	20 (17%)
	Never	---	---	---	---	01 (3%)	---	**01 (1%)**	01 (1%)
	Blank	---	---	---	---	---	---	---	---
Chat	Daily	02 (8%)	05 (29%)	04 (19%)	**11 (17%)**	02 (7%)	-	**02 (3%)**	13 (11%)
	Weekly	07 (27%)	03 (18%)	05 (24%)	**15 (23%)**	01 (3%)	01 (3%)	**02 (3%)**	17 (14%)
	Monthly	03 (12%)	04 (24%)	01 (4%)	**08 (13%)**	05 (19%)	01 (3%)	**06 (11%)**	14 (12%)
	Never	13 (50%)	05 (29%)	10 (48%)	**28 (44%)**	19 (70%)	22 (81%)	**41 (76%)**	69 (58%)
	Blank	01 (4%)	-	01 (4%)	**02 (3%)**	-	03 (11%)	**03 (6%)**	05 (4%)
Word Process	Daily	05 (19%)	06 (35%)	04 (19%)	**15 (23%)**	09 (33%)	08 (30%)	**17 (%)**	32 (27%)
	Weekly	17 (65%)	10 (59%)	14 (67%)	**41 (64%)**	16 (59%)	16 (59%)	**32 (%)**	73 (62%)
	Monthly	04 (18%)	01 (6%)	03 (14%)	**08 (13%)**	02 (7%)	03 (11%)	**05 (%)**	13 (11%)
	Never	---	---	---	---	---	---	---	---
	Blank	---	---	---	---	---	---	---	---
Spread-sheet	Daily	01 (4%)	---	---	**01 (2%)**	02 (7%)	---	**02 (3%)**	03 (3%)
	Weekly	01 (4%)	01 (6%)	---	**02 (3%)**	08 (30%)	05 (19%)	**13 (24%)**	15 (13%)
	Monthly	15 (58%)	09 (53%)	13 (62%)	**37 (58%)**	11 (41%)	15 (56%)	**26 (48%)**	63 (53%)
	Never	06 (23%)	07 (41%)	07 (33%)	**20 (31%)**	05 (19%)	05 (19%)	**10 (19%)**	30 (25%)
	Blank	03 (12%)	---	01 (5%)	**04 (6%)**	01 (3%)	02 (7%)	**03 (6%)**	07 (6%)

Table with all frequencies of Brazilian participant's answers to pre-coded items

Activity	Frequency	BM1	BM2	BT2	BN1	BN2	TOTAL
Email	Daily	06	04	01	07	05	**23**
	Weekly	16	14	01	10	06	**47**
	Monthly	---	07	02	03	06	**18**
	Never	---	---	02	---	03	**05**
	Blank	---	02	01	03	01	**07**
Games	Daily	---	---	---	01	---	**01**
	Weekly	01	02	---	01	02	**06**
	Monthly	14	13	02	09	14	**52**
	Never	04	08	04	09	05	**30**
	Blank	03	04	01	03	00	**11**
Search	Daily	---	04	01	05	04	**14**
	Weekly	16	15	02	11	09	**53**
	Monthly	05	06	03	05	07	**26**
	Never	---	---	---	---	01	**01**
	Blank	01	02	01	02	---	**06**
Chat	Daily	01	---	01	01	---	**03**
	Weekly	01	04	---	---	---	**05**
	Monthly	08	11	01	07	10	**37**
	Never	10	09	04	12	11	**46**
	Blank	02	03	01	03	---	**09**
Spread	Daily	03	02	---	04	01	**10**
	Weekly	01	02	00	00	01	**04**
	Monthly	11	12	03	10	08	**44**
	Never	04	06	03	06	11	**30**
	Blank	03	05	01	03	---	**12**
Word Process	Daily	08	12	01	09	04	**34**
	Weekly	12	09	02	07	12	**42**
	Monthly	02	05	03	05	03	**18**
	Never	---	---	01	---	02	**03**
	Blank	---	01	---	02	---	**03**